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UNITED STATES DEPARTMENT OF AGRICULTURE
CIRCULAR No. 157

Washington, D. C. April, 1931

FIG INSECTS IN CALIFORNIA

By

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Bureau of Entomology

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By PEREZ SIMMONS, *Entomologist*, and W. D. REED, *Associate Entomologist, Division of Stored-Product Insects, and* E. A. McGREGOR, *Associate Entomologist, Division of Tropical, Subtropical, and Ornamental Plant Insects, Bureau of Entomology*

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INTRODUCTION

The industry of producing dried figs in California is beset with several insect enemies and diseases which seriously reduce the quantity of the merchantable crop. It should not be concluded, however, that California dried figs that are shipped to markets throughout the country are undesirable food products by reason of the inroads of pests on the ranches. In order to observe the requirements of regulations based on the national pure food law the dried-fruit-packing industry has been operating a self-imposed inspection service at shipping points, applying to packed dried figs and dried-fig products.

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[1] This circular has been prepared by Perez Simmons and W. D. Reed with the exception of that portion under the heading "Pests attacking green figs and fig trees" (p. 56), which was prepared by E. A. McGregor. The observations recorded in this circular apply especially to the San Joaquin Valley, where most of the dried figs of California are produced. During 1927 and 1928 the writers were assisted in the work on fig insects by George R. Bell, Louis R. Ogren, and Edwin Washburn, students at the Fresno State Teachers' College. Much of the work recorded in Tables 1, 2, and 3 was done by Mr. Washburn. The fundamental research of investigators of the California State Agricultural Experiment Station on the relationships of the dried-fruit beetle to smut and souring has been of much value to the writers. Helpful suggestions have also been found in an unpublished manuscript on the dried-fruit beetle by M. E. Phillips, formerly with the Bureau of Entomology. The chart shown in Figure 26 was lent to the writers by the Office of Plant Pathology, California State Department of Agriculture. The cordial assistance of many fig growers and State and county officials is gratefully acknowledged. The thanks of the writers for identifications of insects are due J. M. Aldrich, of the Division of Insects, U. S. National Museum; E. A. Chapin and August Busck, W. S. Fisher, A. B. Gahan, and C. T. Greene, of the taxonomic unit, Bureau of Entomology; W. L. McAtee, of the Bureau of Biological Survey, and W. M. Mann, of the National Zoological Park. B. J. Howard, of the Food, Drug, and Insecticide Administration, has helped the writers on many occasions, especially in the identification of the diseases of figs, and the photographs reproduced in Figures 1 and 2 were made by him. Figure 25 is a reproduction of an unpublished drawing furnished by E. A. Back and R. T. Cotton, and Figures 33 and 37 are from photographs from F. P. Roullard.

Improved methods of storing, culling, and inspecting dried figs have been adopted by packers whenever possible.

In 1927 and 1928 severe losses were sustained by producers of dried figs in California, the source of practically all dried figs of American origin, on account of the high percentage of unmerchantable fruit in their crops. It is the purpose of this circular to outline what has already been done by investigators in California and by Federal agencies toward improving conditions, to explain our present knowledge of the insects which cause deterioration of figs, both before and after they are dried, and to make suggestions looking toward further improvement.

For the information of readers who may not be familiar with the fig industry, the following short account is given of the varieties of figs and of methods of harvesting and packing.

There are four principal varieties of drying figs in California: Three "white" varieties—the Adriatic, the Calimyrna (the commercial name for the Lob Ingir or common Smyrna fig as grown in California), and the Kadota—and one "black" variety—the Mission. When harvested, figs of the former group range in color from light straw to brown; Mission figs are bluish black with occasional reddish tinges. The Calimyrna requires pollination and consequently produces fertile seeds. The Adriatic, Kadota, and Mission varieties develop perfect fruit without the aid of pollination by the caprifying insect. The Adriatic occupies first place in point of tonnage produced, and is the variety that has been most extensively planted in single or double rows (borders or avenues) along dividing lanes on ranches and along the highways. In orchards fig trees are sometimes interplanted with apricots, pomegranates, or olives.

The fig tree produces each year two distinct crops; a light first crop (brebas) on the old wood and, after several weeks, a heavy main crop on the new wood. The harvest season for figs begins early in June with first-crop, fresh Mission, and continues, especially in the case of the main crop of dried Adriatic, until the cool, rainy weather late in October.

Production of dried figs is centered in the San Joaquin and Sacramento Valleys. The principal concentrations of acreage are in Fresno, Merced, Tulare, and Stanislaus Counties, all in the San Joaquin Valley.

For the production of dried figs the fruit is allowed to ripen and partly dry on the trees, and fall to the ground. (Fig. 1.) It is picked up at intervals of from a few days to a week or more, and spread in the sun on drying trays (fig. 2), then culled and placed, for equalization of moisture, in sweat boxes. Delivery to packing houses begins early in August and continues beyond the end of the calendar year.

Some figs, chiefly of the Adriatic variety, are washed and bleached with sulphur dioxide before being spread on drying trays. In the packing houses figs are usually graded into five sizes and stored in bins holding 20 to 30 tons, or in boxes. The fruit is usually treated with hot water or steam to clean and soften it before it is packed for market. The figs are sold in bulk, or prepared as layers, bricks, or paste (used for making cookies), or put up in fancy packages. A small part of the crop is roasted and ground for use as a substitute for coffee. The culls are widely used as feed for stock, especially hogs.

HISTORICAL

The first figs to be grown in the region that is now California were of the Mission variety, frequently called the Black Mission, and were brought in by Franciscan missionaries (*13*)[2] at an uncertain date in the last third of the eighteenth century. About 1853, three years after the admission of California to statehood, the planting of other varieties of figs began, and, in time, the active interest of the United States Department of Agriculture was enlisted (*13; 24, p. 82*), as well as that of the California State Agricultural Experiment Station (*7*). Accord-

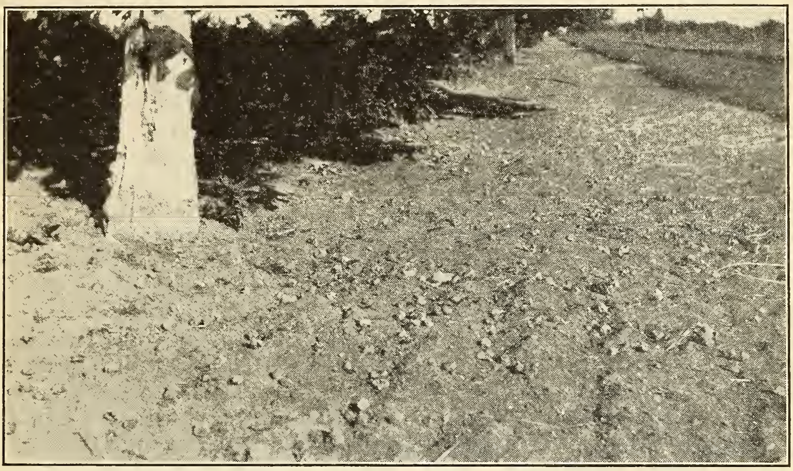

FIGURE 1.—Calimyrna fig trees bordering a vineyard along a highway, showing ripened figs on ground, before being picked up and spread on drying trays. October 13, 1927

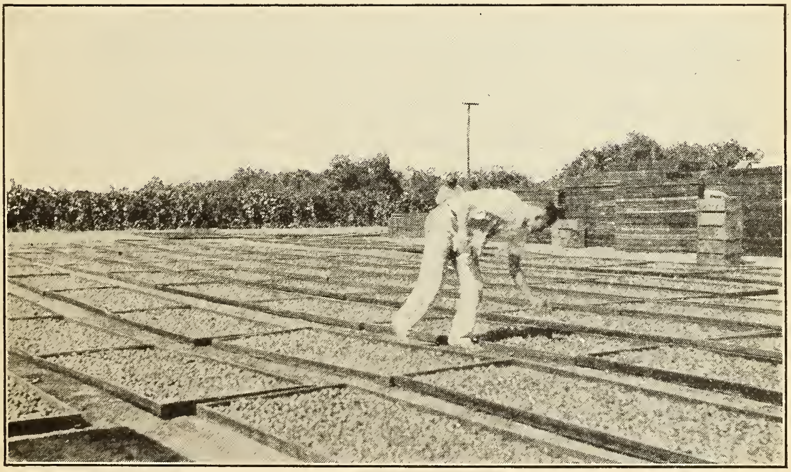

FIGURE 2.—Taking samples of Adriatic figs from drying trays. In background, an avenue of fig trees intersecting a vineyard. August 12, 1927

ing to Condit (*7*), at least 159 different varieties of edible figs had been tested out in California, a considerable number of which he believed to be excellent for use as fresh fruit. The varieties for drying are limited to four—the Adriatic, which leads in importance, the Calimyrna, the Kadota, and the Mission; the last-named, still high in favor, standing second or third in point of production, and esteemed for certainty of crop.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 69.

The excellent quality of figs imported from Smyrna led, in 1880, to the importation of cuttings of the Smyrna variety, and from this beginning has been developed an important industry. The Smyrna or Lob Ingir fig, when propagated in California, was first named California Smyrna. The name was later contracted to Calimyrna, and protected by copyright (*34*).

In the early days of the Smyrna fig in California the fruit produced when the trees came into bearing failed to ripen and dropped from the trees at an early stage of development. Subsequently it came to be realized that the production of mature fruit requires the fertilization of the flowers of the Smyrna fig with pollen from the flowers of male, or caprifig trees, and that, except for artificial pollination, this result is brought about only by the fig insect, *Blastophaga psenes*. Artificial pollination of Smyrna figs was tried in California, beginning in 1890, but was abandoned when the fig insect was successfully imported and established in 1899 (*24*), after some preliminary unsuccessful attempts at introduction.

During the time covered by the foregoing early history, diseases and insect pests of figs in California seem to have received little or no public attention, notwithstanding the presumption that fig growers experienced troubles from some of them. In 1892 the attention of a special agent of the United States Department of Agriculture, then in California, was called to a destructive fermentation of figs which caused them to sour upon the trees and which often resulted in the loss of nearly the entire crop. The fermentation was found to be caused by yeasts, apparently carried to the ripening fruit by insects. Attempts to effect control were without avail (*19, p. 239*).

In 1900 an entomologist from the United States Department of Agriculture spent about eight months, from March to November, at a Calimyrna fig orchard near Fresno, to study the biology of the fig insect and to make general observations. He observed splitting of figs, damage by birds, souring, and infestation by Carpophilus and other beetles, and noticed that wasps and other insects ate holes through the skin of figs that were left on the ground longer than a day or two (*24*). Because of these and other losses, he estimated that only about half of the season's crop was saved in that orchard.

About 1905 the Mediterranean fig scale was introduced, supposedly on imported cuttings (*35*). The dried-fruit beetle was first reported to be abundant in 1907 (*39*).

As the years passed, various Federal and State entomologists and plant pathologists conducted studies on insects and diseases more or less directly involving figs. In 1911 a systematic investigation of the insect enemies of dried fruit in California was undertaken by the Bureau of Entomology, United States Department of Agriculture, which in 1915 published a bulletin on the subject (*31*). In 1922 this bureau established at Fresno a laboratory for the investigation of dried-fruit insects, and in 1927 it undertook specific work on fig insects, with emphasis on the dried-fruit beetle. During the first year of the work on fig insects financial assistance was contributed by the Dried Fruit Association of California. Since 1925, observations and control experiments on insect pests of fig trees and of green figs have been conducted by the Bureau of Entomology in the vicinity of the bureau's field laboratory, at Lindsay, established for the study of citrus insects. In 1912 the California State Commission of Horticulture published a report on the life history and control of the root-knot nematode, *Heterodera radicicola*, a pest of fig trees and other plants (*30*). A report on black smut of figs was published by the same commission in 1918 (*23*). Investigations of smut and of souring of figs continued, and in 1925 a bulletin on fig smut (*32*), issued by the California State Agricultural Experiment Station, set forth more fully the relation of these diseases to insects, especially to the dried-fruit beetle, and gave conclusions drawn from various experiments on control. A fig blister mite was reported in 1922 (*17*). In the next year an internal rot (endosepsis) of the Smyrna fig in California was discovered, a disease which was found to be spread by Blastophaga. A report of it was published in 1925 (*4*). In 1926 the development of a method for the control of this disease was begun by the California State Agricultural Experiment Station, with financial assistance from the California Peach and Fig Growers' Association.

A few figures from the California Crop Report for 1927 (*26*) will suggest the economic importance attained by the fig crop in California in recent years. In 1926 the production of dried figs in the State totaled approximately 11,350 tons, and represented an estimated farm value of $1,078,000. The production was still greater in 1927, but the farm value was less, largely owing to defects in the fruit. In both years the salability of the crop was impaired by smut, rot, and infestation. In 1927 approximately 3,100 tons of figs were canned and 116 carloads of fresh figs were sent out of the State. The total acreage of figs in 1928 was estimated at 62,204 (50,513 acres bearing, 11,691 nonbearing).

A self-imposed inspection of growers' deliveries and of packed figs, and improved methods of handling dried figs in storage to prevent increased damage by insects, were adopted by many packers of figs during 1927.

In the same year an investigation of souring of figs, and of various rots and molds, with special reference to the possible influence of mites and thrips, was begun by the California State Agricultural Experiment Station.

In 1927, also, the California fig clean-up committee, representing growers, the California State Department of Agriculture, the California State Agricultural Experiment Station, the Extension Service of the University of California, the California Peach and Fig Growers' Association, the Dried Fruit Association of California, and county agricultural commissioners, was organized, and a state-wide campaign to reduce endosepsis was made under its direction. After the close of this campaign the committee, amplified by representation from the United States Department of Agriculture, continued as an organization to help the fig industry.

DIFFICULTY OF CONTROL OF INSECTS AND DISEASES

To the reader familiar with the production of dried figs a survey of the foregoing historical outline may suggest that a considerable number of investigations of fig diseases and insect pests have been made without, in some respects, satisfactory progress in control. Such an inference is to a large extent justified. The fig fruit is, by reason of its structure, a peculiarly difficult one to protect from the insects and diseases which attack its interior. The insects and disease organisms that are most destructive enter the figs through the apical opening or eye. The larger the figs, the higher the percentage of damaged fruit. To effect control, insect pests must be prevented from entering figs and, so far as the insects that attack figs in orchards are concerned, satisfactory ways and means for accomplishing this result have not yet been found. In the case of the Mission and Kadota varieties, the eye is frequently sufficiently closed by bractlets to prevent the entrance of most species of insects that visit ripening figs.

CLOSE ASSOCIATION OF INSECTS AND DISEASES

Not only does the fig, in the case of the Smyrna variety, exhibit remarkable dependence upon the caprifying insect, Blastophaga, but there is no other example, at least in the United States, of so extensive an association between insects and diseases as exists in the case of those attacking the fruit of the fig. On the one hand, the most destructive diseases (fig. 3) appear to be dependent upon insects for communication to figs, and, on the other hand, one of the insects may be said to rely largely upon the occurrence of souring (fig. 3, B), one of the most prevalent diseases of Adriatic and Calimyrna figs. (See discussion of vinegar flies, p. 26.)

Although research in these matters has not advanced far enough to warrant an unqualified statement that there would be no diseases of the fruit of the fig if there were no insects in fig orchards, most of the evidence that has been assembled thus far points toward such a conclusion.

CLASSIFICATION OF CAUSES OF INJURY

In the following classification the more important insect pests and diseases and other troubles of figs and fig trees in California are listed in groups on the basis of their principal point of attack:

Pests attacking the inside of the fruit in the orchard.—Dried-fruit beetle (*Carpophilus hemipterus* L.), and other small beetles, mostly of the family Nitidulidae; souring (resulting from fermentation caused by yeasts and bacteria); smut and molds (*Aspergillus niger* Van Tiegh., and other fungi); endosepsis or internal rot (*Fusarium moniliforme* Sheld., var. *fici* Caldis); vinegar flies (*Drosophila melanogaster* Meig., and other species of Drosophila); thrips (*Frankliniella tritici* Fitch, and others); mites (*Eriophyes fici* Essig and an eupodid mite).

Pests attacking the outside of the fruit, in the orchard.—Birds; Mediterranean fig scale (*Lepidosaphes ficus* Sign.); small darkling beetle (*Blapstinus fuliginosus* Casey); Pacific red spider (*Tetranychus pacificus* McG.); thrips (*Frankliniella tritici* Fitch, and others).

Insects attacking the inside of dried, or partially dried, harvested figs.—Indian-meal moth (*Plodia interpunctella* Hübn.); fig moth (*Ephestia cautella* Walker); dried-fruit beetle (*Carpophilus hemipterus* L.); saw-toothed grain beetle (*Oryzaephilus surinamensis* L.).

Physiological imperfections of the fig fruit.—Splitting (due to too great turgor or pressure of sap); meatlessness (puff-ball figs), apparently caused, in some cases, by insufficient moisture in the soil, or by undercaprification.

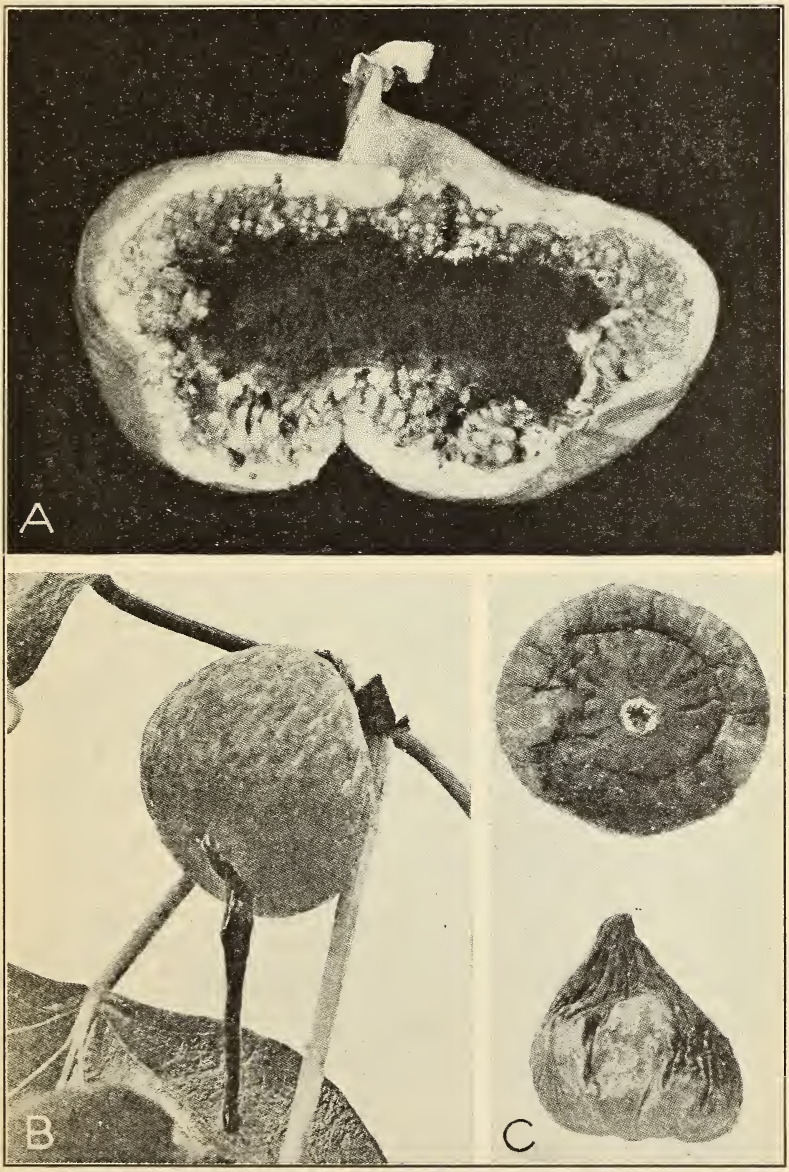

FIGURE 3.—Diseases of figs: A, Black smut (*Aspergillus niger*), × 1½; B, souring (Smith and Hansen), × ¾; C, endosepsis (*Fusarium moniliforme*, var. *fici*) (Caldis), × ¾

Organisms injuring the fig tree.—Mediterranean fig scale (*Lepidosaphes ficus* Sign.); Pacific red spider (*Tetranychus pacificus* McG.); die-back of twigs (*Botrytis cinerea* Pers. and *Sclerotinia libertiana* Fuckel); nematodes (*Caconema radicicola* (Greef) Cobb) cause root knot; crown gall (*Bacterium tumefaciens* Er. Sm. and Towns.); gophers cause injury to the roots.

Other insects and fungi occasionally attack the trees and the fruit. The green "moss" (several species of lichens) that grows on the trunk and branches is believed by some to be injurious to the health of the trees. Injury to the trees is sometimes caused by frost and by sunburn. Young trees are occasionally girdled by jack rabbits, and the fruit is taken to some extent by ground squirrels.

In the foregoing classification there is some overlapping from one division to another. As examples, endosepsis frequently involves the outside portion of figs; birds and Blapstinus beetles feed upon the interior pulp.

CLASSIFICATION OF THE INSECT PESTS OF FIG FRUIT

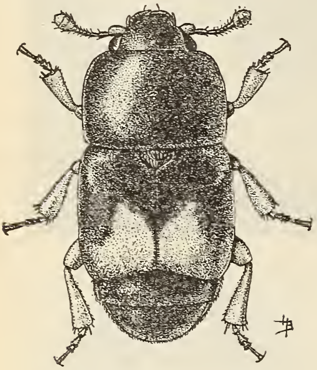

FIGURE 4.—The dried-fruit beetle (*Carpophilus hemipterus*). × 13

As is the case with many organic materials the chemical composition and physical character of which change with the passage of time, a number of insects attack in succession the fruit of the fig. In the following list these insects are arranged according to the condition of the fruit attacked.

First group, for the most part attacking green figs: Mediterranean fig scale, mites (*Eriophyes fici*, etc.), Pacific red spider, and thrips.

Second group, attacking ripening and partially dried figs: Dried-fruit beetles, vinegar flies, and small darkling beetle.

Third group, attacking well-dried, harvested figs: Indian-meal moth, fig moth, saw-toothed grain beetle; dried-fruit mite and dried-fruit moth (not common); dried-fruit beetle and vinegar flies (infestation originated when the figs contained more moisture).

Fourth group, attacking decaying figs: Dried-fruit beetles, vinegar flies, and various species of scavengers, including the larvae of flies of the genera Hermetia Leptocera, and Scatophaga, and miscellaneous beetles.

INSECTS ATTACKING RIPENING AND PARTIALLY DRIED FIGS

THE DRIED-FRUIT BEETLE [3]

Of the several insects by which California figs are damaged before they are dried and stored in boxes or bins, the dried-fruit beetle (figs. 4, 5, and 6) is the most important. This species is distributed in many parts of the world, and it has been definitely recorded as a serious pest of figs in California, at least since 1907, when it was mentioned (*39*) as abundant in that State. It was probably included among the beetles of the genus Carpophilus which Schwarz (*24, p. 94*), observed in 1900.

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[3] *Carpophilus hemipterus* (L.); family Nitidulidae. There are at least five other species of Nitidulidae which frequent the same type of food material in the San Joaquin Valley, but none of them is so abundant as the dried-fruit beetle. These species include *Carpophilus discoideus* Lec., *C. rickseckeri* Fall, *C. nitens* Fab., *C. dimidiatus* (Fab.), and *Epuraea* (*Haptoncus*) *luteola* Er. The last two are the most common. Edwin C. Van Dyke, of the University of California, kindly furnished the determination of Epuraea. In a letter to Professor Van Dyke, H. C. Fall stated (March, 1929) that he had specimens from Florida, Alabama, Texas, and southern California; that his specimens from Pasadena and Elsinore dated from 1917; and that the species was becoming widely dispersed in the warmer parts of the country.

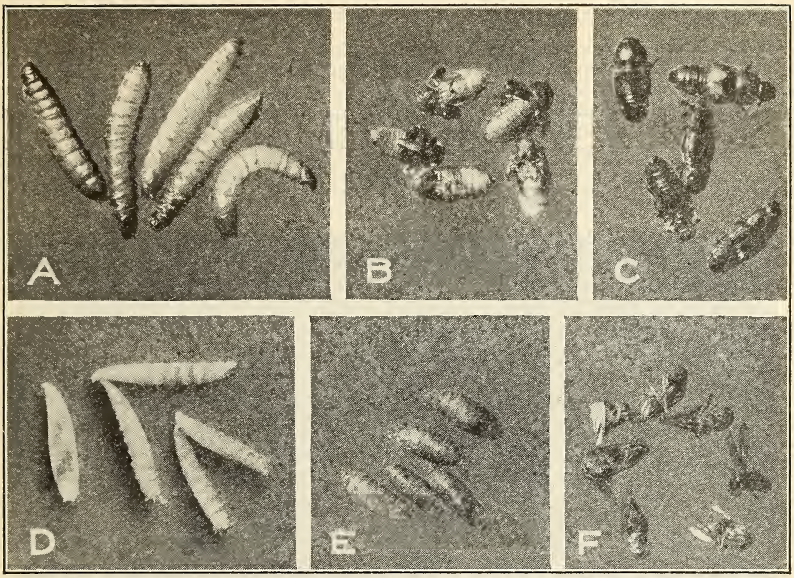


FIGURE 5.—The chief insect pests of ripening figs: A, B, C, Larvae, pupae, and adults, respectively, of the dried-fruit beetle (*Carpophilus hemipterus*); D, E, F, larvae, puparia (inclosing the pupae), and adults of a vinegar fly (Drosophila). × 3.9

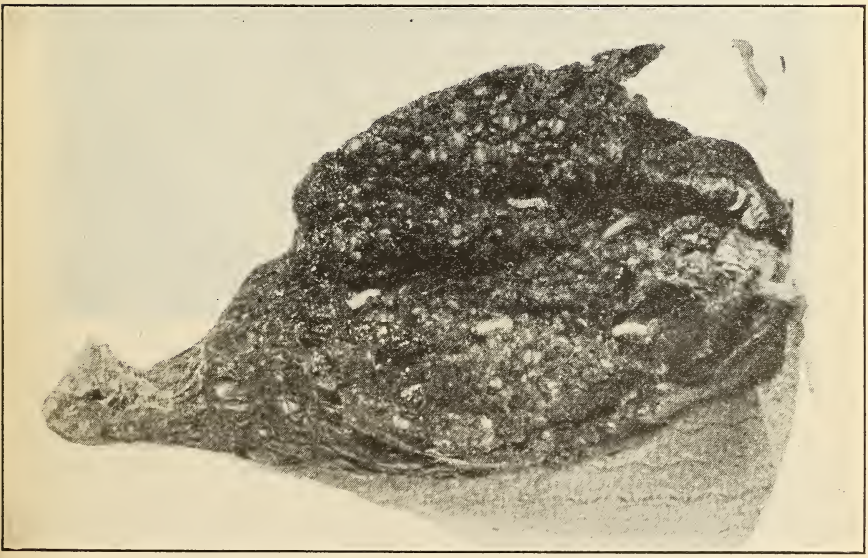


FIGURE 6.—Larvae of the dried-fruit beetle (*Carpophilus hemipterus*) in a ripe fig. × 2

DESCRIPTION

The following description of the larvae, pupae, and adults of the dried-fruit beetle is adapted from that of Essig (*14*).

Larvae.—The newly hatched young are slightly less than one-sixteenth inch (1¼ to 1½ mm.) long, and are white or transparently yellowish in color. The mature forms attain an average length of about one-fourth inch, and are white or yellowish, with the head and posterior tip of the body rich amber brown. The body is sparsely clothed with spinelike hairs. There are two large tubercles at the extreme posterior end of the abdomen and two smaller tubercles just in front of the larger ones. All stages of the larvae are active, move quickly, and disappear in a surprisingly short time when disturbed.

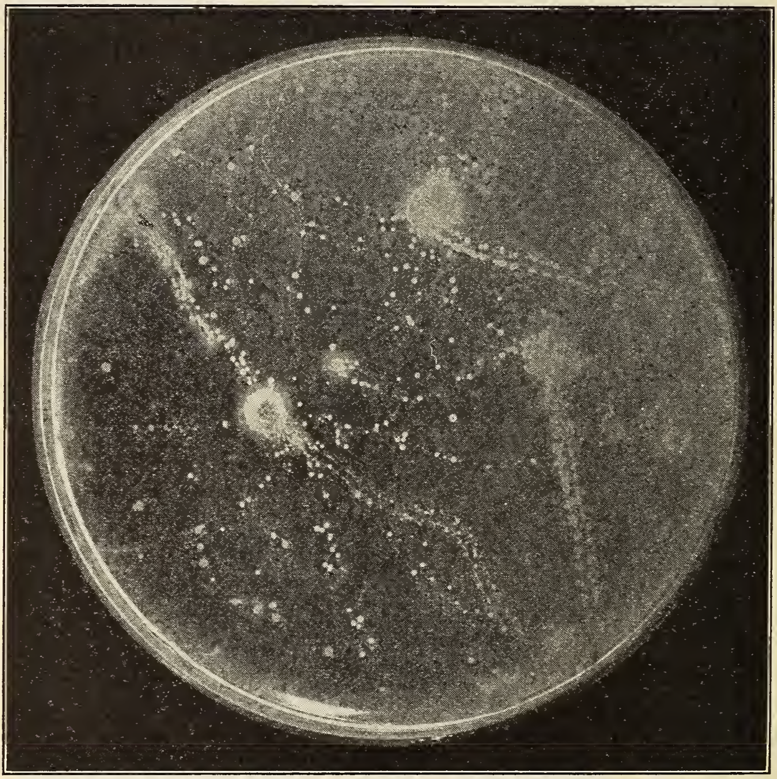


FIGURE 7.—Culture plate showing endosepsis and other organisms growing in tracks made by dried-fruit beetles (*Carpophilus hemipterus*) that were removed from ripening Calimyrna figs infected with endosepsis. Approximately natural size. Experiment made by B. J. Howard, September 6, 1927

Pupae.—The pupae are robust, oval, somewhat spiny, and about one-eighth inch long. The color is white or pale yellow until the pupae are nearly mature, when the dark shades of the adult are gradually assumed.

Adults.—The beetles are small, averaging about one-eighth inch in length and half as much in width. They are oval or robust, and dull or shining black in color, with two conspicuous amber-brown spots at the posterior tips of the elytra or wing covers, and two smaller, more obscure spots of the same color at the lateral margins of the wing covers, near their bases. Very often the large spots run together to form a single area, and the small spots are sometimes obscure. In the newly emerged adults all of the spots appear like shining silver, then gradually become orange or amber brown and finally dark brown. The antennae and legs are reddish or amber. The surface of the body is finely punctate, the small circular pits being visible only under a microscope or strong hand lens. From each puncture there arises a small hair. The most conspicuous characteristic of the structure of the beetles is the very short elytra, which do not reach to the tip of the abdomen. On the tibiae of the legs, especially the middle and hind pairs, there are a number of spines.

RELATION TO FIG DISEASES

The general conclusions of the investigators who have studied smut and souring are that, principally through the agency of insects, the figs on the trees become inoculated with the reproductive units of the organisms that cause smut and souring. The insects concerned, chiefly dried-fruit beetles, become dusted or smeared with fungous spores, yeast cells, or bacteria which are so abundant and well distributed that the insects may be said to be invariably contaminated with some of them. (Fig. 7.) When the beetles are inside of figs, some of these disease germs are lost from their bodies through contact with the pulp of the fig. If the pulp has a favorable sugar content, the organisms grow and, if suitable sugar concentrations continue long enough, produce a condition of disease.

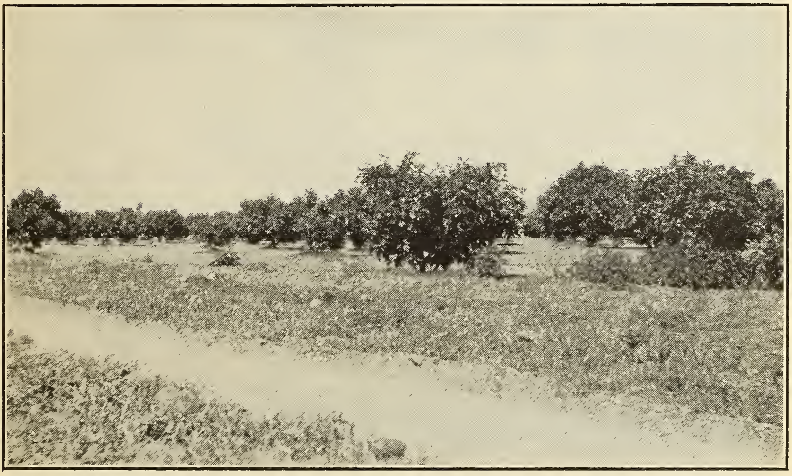


FIGURE 8.—Orchard of Adriatic figs next to a field of watermelons. The type of souring usually found in figs near watermelons (characterized by a bright red color and very sharp acid odor) decreased in this orchard as the distance from the melon field increased. August 28, 1927

The statement has been made by Phillips, Smith, and Smith (*32, p. 25*) that organisms causing fig diseases always develop in great abundance in cultures made from dried-fruit beetles. They stated also that "in the few cases which have ever been seen of an Adriatic fig orchard where practically all the fruit was sound, no dried fruit beetles could be found." The writers of this circular observed such a condition in 1928. A well-irrigated Adriatic orchard produced good-sized, succulent figs which were, on August 25, 95 per cent perfect without culling. No dried-fruit beetles were found in the figs, and none were present on that date in several traps in the orchard.

OCCURRENCE AND BEHAVIOR

Larvae and adults of the dried-fruit beetle occur abundantly in most plantings of figs, especially those of the Adriatic variety, from the beginning of ripening of the first crop to the time of the fall rains

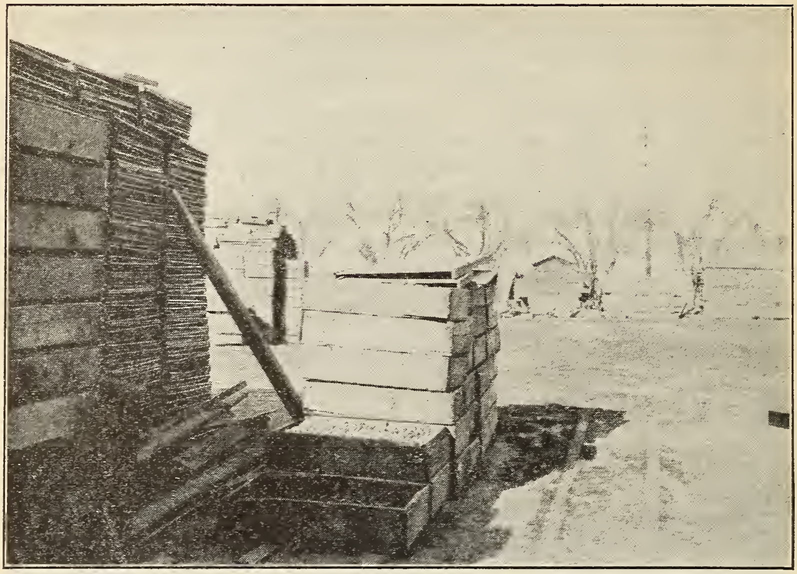


FIGURE 9.—Cull figs in sweat boxes. Storage under these conditions is likely to result in the wetting of the fruit by rain, which produces a condition favorable for the breeding of dried-fruit beetles (*Carpophilus hemipterus*). In background, fig trees along highway. February 21, 1929

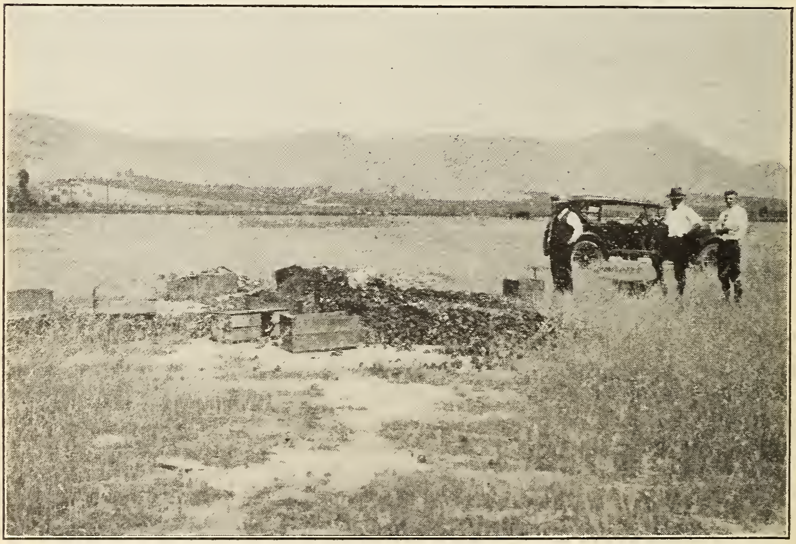
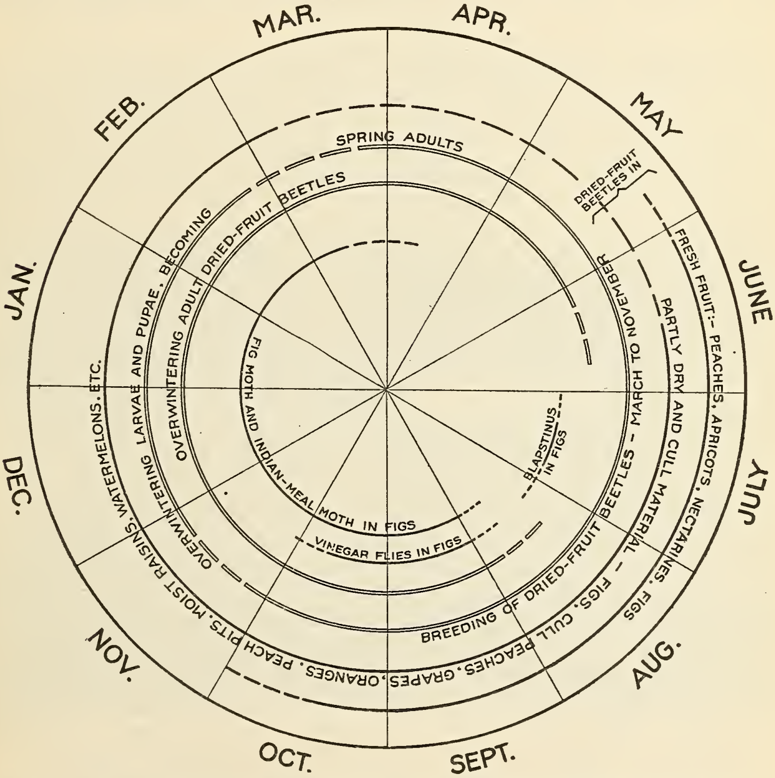


FIGURE 10.—A small orange dump. Many dried-fruit beetles (*Carpophilus hemipterus*) were present in the piled fruit, which was decaying after having been wet by winter rains. Oranges that are spread more thinly in the sun tend to become dry and hard and unsuitable for breeding the dried-fruit beetle. May 11, 1928

late in October or in November. By careful search the eggs and pupae may usually be found, the former in ripening figs and the latter in the soil. During the part of the year most favorable for the development of the dried-fruit beetle, when ripening figs are abundant and temperatures high, the population of the beetle is, as a general rule, much greater in fig orchards than anywhere else in the San Joaquin Valley. The beetle population in orchards sometimes fluctuates markedly, for reasons not well understood.

Many beetles are found also in watermelon fields (fig. 8), in cull figs (fig. 9), peaches, and apricots, in piles of pits of the stone fruits, in orange dumps (fig. 10), and in similar accumulations of fermenting fruit. Figure 11, based on information assembled up to March 31, 1929, shows the approximate year-round status of dried-fruit beetles and certain other fig insects on ranches, and the seasonal distribution of their food.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APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
SPRING ADULTS
DRIED-FRUIT BEETLES
OVERWINTERING LARVAE AND PUPAE, BECOMING
OVERWINTERING ADULT DRIED-FRUIT BEETLES
OVERWINTERING
DRIED-FRUIT BEETLES IN
FRESH FRUIT:- PEACHES, APRICOTS, NECTARINES, FIGS
PARTLY DRY AND CULL MATERIAL – FIGS, CULL PEACHES, GRAPES, ORANGES, PEACH PITS, MOIST RAISINS, WATERMELONS, ETC.
BREEDING OF DRIED-FRUIT BEETLES – MARCH TO NOVEMBER
BLAPSTINUS IN FIGS
FIG MOTH AND INDIAN-MEAL MOTH IN FIGS
VINEGAR FLIES IN FIGS

FIGURE 11.—Diagram showing year-round status of fig insects on ranches, and seasonal distribution of their food. (Based on information obtained to April, 1929)

The fall rains tend to leach out the figs that remain on the trees and on the ground. These washed-out figs are not very attractive to the beetles, although a few adults and larvae may be found in them. "Stick-tight" figs, which remain all winter on the trees, harbor some beetles; but these, as well as figs scattered on the ground, become so changed by drying or decomposition during the winter that by March or April they have become unsuitable material for the breeding of dried-fruit beetles.

During the latter part of fall and in the winter, when fig plantings contain little attractive food material, the insects may be found in old melons, fruit dumps, decaying pomegranates, moist raisins, etc. Considerable quantities of cull figs and of raisins were present on some ranches during the winter of 1927–28. However, there is a period in the spring (fig. 11) when very little breeding material for beetles is ordinarily available in the San Joaquin Valley. Notwithstanding the apparent scarcity of cull fruit in the spring, beetles in large numbers were present throughout the fig-growing sections visited by the writers in May and June, 1928, and these insects attacked the figs as soon as ripening began.

The presence of large numbers of beetles in the earliest ripe figs could not be satisfactorily explained with the information available when the writers began to study the behavior of the beetles in fig plantings in June, 1927. The insects appeared promptly in the first ripening figs, from a countryside that had been practically devoid of breeding materials for several months. In 1928, traps placed in fig plantings on 18 ranches distributed from Modesto to Porterville caught large numbers of beetles in May before either figs or other fruits were ripe. Observations on the life history of the beetles, recounted in paragraphs which follow, serve to explain their presence at such a time. The evidence seems to justify the conclusion that a portion of the beetles that come to the earliest ripening figs are adults that survive the winter, the remainder being either spring adults (fig. 11) that result from overwintered larvae and pupae or adults that develop from eggs laid in the spring.

LENGTH OF LIFE

The writers have had under observation adult dried-fruit beetles that have undoubtedly survived for more than a year. Of a considerable number of adults, probably at least 3 months old, collected from decaying watermelons February 21, 1928, two lived until January 5, 1929. These beetles were given food; beetles collected at the same time and given water but no food, beginning March 10, lived through April 30 but were all dead by June 11, 1928. For beetles to live so long may be exceptional out of doors, but there is little doubt that adults survive in small numbers from September and October to the beginning of the following fig harvest.

As shown in Table 1, female beetles mated on various dates from May 4 to September 21 lived an average of 103.3 days, while the longevity of the males was nearly 145.6 days. Two unmated females which emerged May 5, 1928, lived more than eight months. All of these insects were fed with fermenting dried peaches.

OVERWINTERING

As already stated, adults are present during the winter in decaying melons, cull figs, moist raisins, and similar material. They are present in considerable numbers in raisins stored in warehouses and under sheds. Larvae also may be found, especially in such favorable situations as accumulations of moist cull figs. For the most part the pupae overwinter in the soil. After larvae become full-grown they usually enter the soil to pupate and transform to beetles. When this occurs in the fall, the change to the adult stage is delayed by the low temperatures until spring.

On February 5, 1928, the writers found many pupae, but no larvae, in the top inch of heavy soil in an area where cull figs had been set out in boxes in the preceding fall. (Fig. 12.) No figs had been there since the preceding December. A cage, inclosing a trap, was placed over part of the area; the beetles began to emerge from the soil between February 20 and March 8. Pupae were found in other similar locations in February and March, but a careful search of soil under fig trees in several localities, where considerable late fruit had been allowed to decay on the ground, resulted in but two or three pupae being found.

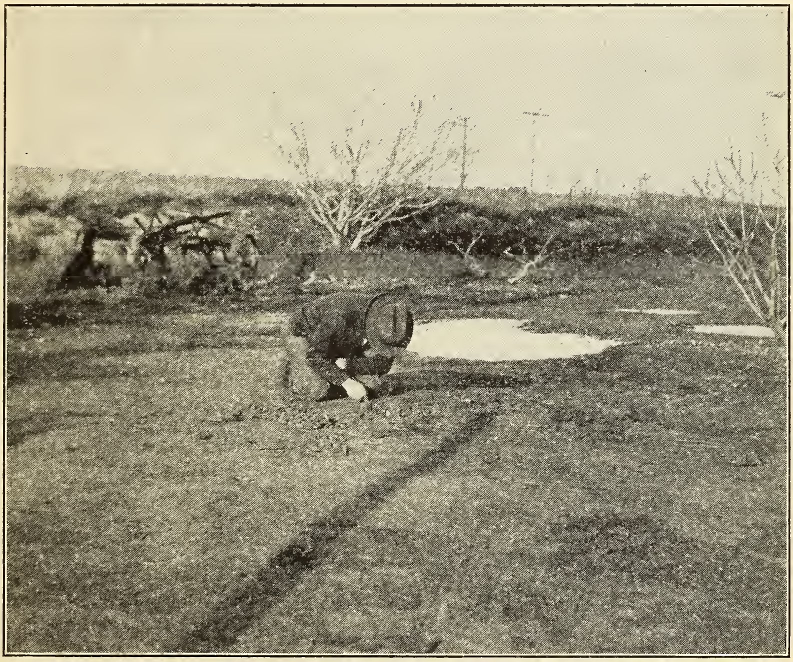

Figure 12.—Location of overwintered pupae of the dried-fruit beetle (*Carpophilus hemipterus*). Cull figs had been laid out in boxes on this ground during the preceding fall and had been removed in December. Pupae were abundant in the upper inch of soil when the scene was photographed. February 5, 1928

Adults collected from watermelons in February, 1928, were placed in an incubator at a temperature of about 80° F., and progeny began to appear within a few days. Several hundred adults were carried over the winter of 1928–29 in fermenting dried peaches contained in covered cans placed out of doors. The first lot was so placed on November 15, and the first breeding occurred between March 1 and March 15. Breeding in other lots of beetles was at a low ebb after November 1 and ceased entirely about November 30. The temperatures during the winter were below normal; increase of dried-fruit beetles was at a standstill for about three months.

EGG LAYING

The small white eggs of the dried-fruit beetle are scattered over the surface of the food material. They may be found on the pulp of ripe figs on the tree. Unmated females do not lay eggs, according to the writers' observations of a few individuals. In the case of one segregated pair, the male died when the female was still actively producing eggs, and oviposition ceased within a few days. A new male was provided after a lapse of three weeks, whereupon egg laying began again on the following day. (Table 1, female No. 5.)

Table 1 presents data concerning the life history and oviposition of 21 mated females. The smallest number of eggs deposited was 461, the greatest 2,134, and the average 1,071. These eggs were laid on fermented dried peaches, each pair of beetles being confined in a separate container. Eighty-nine per cent of the eggs produced larvae. The length of time between the date the pairs were mated and the beginning of egg laying ranged from 1 to 8 days, the average time being 3.2 days.

Eggs continued to be laid during periods that ranged in length from 18 to 122 days (average 61.3 days), and the average time between cessation of laying and the death of the females was 38.9 days. The greatest number of eggs laid in one day was 66. The last eggs were laid November 29.

Examples of the detailed records of five mated females, illustrating the rate and duration of egg laying, are given in Table 2.

TABLE 1.—*Data on the life history of 21 mated pairs of the dried-fruit beetle, Carpophilus hemipterus, on fermented dried peaches, at Fresno, Calif., in 1928*

Pair No.	Date of emergence		Pre-oviposition period	Oviposition period	Post-oviposition period	Longevity		Total eggs laid	Percentage of hatch	Incubation period			Average daily mean temperature during life of female
	Male	Female				Male	Female			Maximum	Minimum	Average[1]	
			Days	*Days*	*Days*	*Days*	*Days*	*No.*	*P. ct.*	*Days*	*Days*	*Days*	*°F.*
1	May 4	May 3	8	109	17	191	134	1,578	87.3	5	1	2.0	81.8
2	May 5	May 5	4	71	6	82	81	1,139	90.5	4	1	1.9	81.7
3	May 7	May 7	8	21	2	(2)	31	473	99.6	3	1	1.7	78.9
4	do	May 13	4	67	59	139	130	1,703	65.5	5	1	2.1	82.4
5	May 6	do	4	57	36	(3)	97	538	90.0	4	1	2.2	82.7
6	May 14	May 14	3	19	2	135	24	500	99.4	3	1	1.7	80.8
7	June 1	June 1	3	72	42	196	117	1,880	96.4	3	1	1.7	81.5
8	June 2	June 3	1	79	5	163	85	2,134	97.0	4	1	1.8	82.6
9	July 15	July 15	1	36	7	188	44	1,202	95.0	3	1	1.6	85.7
10	do	July 16	1	62	103	171	166	1,547	94.4	4	1	1.7	70.2
11	July 19	July 19	1	50	42	(2)	93	1,065	91.5	4	1	1.7	83.8
12	do	do	3	27	4	(2)	34	848	90.8	3	1	1.6	86.0
13	do	do	2	122	34	174	158	1,766	76.9	3	1	1.6	71.7
14	Aug. 17	Aug. 17	2	18	20	155	40	614	92.7	3	1	1.7	81.4
15	do	Aug. 18	2	87	67	158	156	1,205	94.4	5	1	2.4	61.4
16	do	Aug. 20	2	45	94	146	141	882	96.3	4	1	2.0	65.0
17	do	do	2	82	58	109	142	1,415	93.6	6	1	2.4	64.8
18	Sept. 19	Sept. 19	5	65	64	141	134	461	85.6	7	1	3.7	58.5
19	Sept. 20	do	4	66	41	94	111	537	77.8	6	1	3.6	60.6
20	Sept. 21	do	4	67	46	91	117	501	70.6	6	1	3.3	59.7
21	do	Sept. 20	3	65	67	142	135	502	91.8	6	1	3.5	58.3
Average			3.2	61.3	38.9	145.6	103.3	1,071	89.4	4.3	1	2.2	

[1] The average of the incubation records of all eggs laid by 1 female.

[2] Longevity not recorded.

[3] The male of pair No. 5 escaped May 19, 1928. The female ceased egg laying June 4 and laid no eggs for 21 days. A male was placed with this female on June 25, and egg laying began on June 26. This would indicate that frequent mating is necessary in order that the maximum number of eggs may be laid.

TABLE 2.—*Record of deposition of eggs on fermented dried peaches by five female dried-fruit beetles, Fresno, Calif., 1928*

Date of oviposition	Eggs laid by female of pair No.—				
	5 [1]	6 [2]	7 [3]	8 [4]	9 [5]
May 18	9	35	--------	--------	--------
19	9	6	--------	--------	--------
20	27	27	--------	--------	--------
21	27	26	--------	--------	--------
22	23	22	--------	--------	--------
23	22	20	--------	--------	--------
24	27	22	--------	--------	--------
25	50	27	--------	--------	--------
26	37	23	--------	--------	--------
27	46	47	--------	--------	--------
28	17	31	--------	--------	--------
29	9	30	--------	--------	--------
30	1	23	--------	--------	--------
31	--------	15	--------	--------	--------
June 1	6	21	--------	--------	--------
2	--------	33	--------	--------	--------
3	--------	21	--------	--------	--------
4	3	35	--------	--------	--------
5	--------	36	16	13	--------
6	--------	--------	33	42	--------
7	--------	--------	44	51	--------
8	--------	--------	26	42	--------
9	--------	--------	34	25	--------
10	--------	--------	40	43	--------
11	--------	--------	19	16	--------
12	--------	--------	7	8	--------
13	--------	--------	20	23	--------
14	--------	--------	19	26	--------
15	--------	--------	18	--------	--------
16	--------	--------	13	28	--------
17	--------	--------	14	25	--------
18	--------	--------	27	23	--------
19	--------	--------	17	32	--------
20	--------	--------	18	33	--------
21	--------	--------	24	23	--------
22	--------	--------	20	28	--------
23	--------	--------	34	31	--------
24	--------	--------	19	28	--------
25	--------	--------	27	38	--------
26	27	--------	34	40	--------
27	5	--------	15	16	--------
28	11	--------	7	6	--------
29	17	--------	18	17	--------
30	21	--------	19	28	--------
July 1	16	--------	16	19	--------
2	16	--------	28	26	--------
3	26	--------	23	29	--------
4	19	--------	20	20	--------
5	12	--------	29	25	--------
6	16	--------	23	26	--------
July 7	13	--------	15	30	--------
8	7	--------	33	28	--------
9	12	--------	37	47	--------
10	--------	--------	32	32	--------
11	2	--------	31	39	--------
12	2	--------	20	23	--------
13	3	--------	27	44	--------
14	--------	--------	31	31	--------
15	--------	--------	40	42	--------
16	--------	--------	56	53	--------
17	--------	--------	40	44	14
18	--------	--------	38	6	21
19	--------	--------	25	33	22
20	--------	--------	38	45	37
21	--------	--------	38	31	31
22	--------	--------	52	46	37
23	--------	--------	30	37	44
24	--------	--------	29	32	34
25	--------	--------	32	26	14
26	--------	--------	29	17	14
27	--------	--------	46	40	50
28	--------	--------	45	49	38
29	--------	--------	44	45	33
30	--------	--------	51	29	54
31	--------	--------	40	47	38
Aug. 1	--------	--------	31	32	45
2	--------	--------	28	34	33
3	--------	--------	13	38	39
4	--------	--------	27	23	31
5	--------	--------	23	26	19
6	--------	--------	21	24	39
7	--------	--------	31	18	44
8	--------	--------	16	17	50
9	--------	--------	20	21	37
10	--------	--------	20	28	32
11	--------	--------	14	12	31
12	--------	--------	10	40	45
13	--------	--------	3	38	38
14	--------	--------	3	20	47
15	--------	--------	--------	24	38
16	--------	--------	--------	5	19
17	--------	--------	--------	7	--------
18	--------	--------	--------	--------	30
19	--------	--------	--------	--------	27
20	--------	--------	--------	--------	43
21	--------	--------	--------	--------	34
22	--------	--------	--------	1	--------
Total	538	500	1,880	2,134	1,202

[1] Female No. 5 emerged May 13 and died Aug. 18.
[2] Female No. 6 emerged May 14 and died June 7.
[3] Female No. 7 emerged June 1 and died Sept. 25.
[4] Female No. 8 emerged June 3 and died Aug. 27.
[5] Female No. 9 emerged July 15 and died Aug. 28.

DURATION OF DEVELOPMENTAL PERIODS

INCUBATION PERIOD

As shown in Table 1, the incubation periods of all hatched eggs laid by 21 females ranged from 1 to 7 days in length, with an average of 2.2 days. These records of incubation periods are the result of observations on 20,106 hatched eggs (89.4 per cent of the 22,490 eggs laid by the 21 females).

Detailed records of the development of 38 eggs (Table 3) show an average incubation period of 1.9 days.

TABLE 3.—*Data on development of the dried-fruit beetle on fermented dried peaches at Fresno, Calif., 1928*

Rearing No.	Date egg was laid	Incubation period	Larval period	Pupal period	Date adult emerged	Sex	Period from egg to adult			
							Duration	Temperature		
								Mean, maximum	Mean, minimum	Mean
		Days	*Days*	*Days*			*Days*	°*F.*	°*F.*	°*F.*
1	May 13	2	10	8	June 2	Female	20	88.6	69.4	79.0
2	May 15	0	10	7	June 1	Male	17	88.7	69.6	79.1
3	do	0	10	7	do	Female	17	88.7	69.6	79.1
4	do	0	10	6	May 31	do	16	88.7	69.7	79.2
5	May 27	2	10	11	June 19	do	23	90.9	70.4	80.6
6	do	2	9	11	June 18	do	22	90.9	70.4	80.6
7	do	2	9	10	June 17	Male	21	91.0	70.4	80.7
8	do	2	10	11	June 19	Female	23	90.9	70.4	80.6
9	do	2	9	11	June 18	do	22	90.9	70.4	80.6
10	June 26	2	11	6	July 15	Male	19	92.7	71.7	82.2
11	do	2	11	6	do	Female	19	92.7	71.7	82.2
12	do	2	12	6	July 16	do	20	93.1	72.1	82.6
13	do	2	11	6	July 15	Male	19	92.7	71.7	82.2
14	do	2	11	6	do	do	19	92.7	71.7	82.2
15	July 8	3	6	6	July 23	do	15	97.5	75.4	86.4
16	July 9	2	7	5	do	do	14	97.6	73.3	85.4
17	do	2	8	5	July 24	do	15	97.7	75.3	86.5
18	do	2	7	6	do	do	15	97.7	75.3	86.5
19	do	2	7	5	July 23	do	14	97.6	75.3	86.4
20	do	2	6	7	July 24	do	15	97.7	75.3	86.5
21	do	2	7	5	July 23	Female	14	97.6	75.3	86.4
22	July 31	2	9	6	Aug. 17	Male	17	96.9	74.5	85.7
23	do	2	10	5	do	Female	17	96.9	74.5	85.7
24	do	2	11	7	Aug. 20	do	20	97.1	74.5	85.8
25	do	2	10	5	Aug. 17	Male	17	96.9	74.5	85.7
26	do	2	9	9	Aug. 20	Female	20	97.1	74.5	85.8
27	do	2	10	5	Aug. 17	Male	17	96.9	74.5	85.7
28	do	2	10	5	do	do	17	96.9	74.5	85.7
29	do	2	10	5	do	do	17	96.9	74.5	85.7
30	do	2	10	6	Aug. 18	Female	18	97.1	74.5	85.8
31	Aug. 30	2	12	7	Sept. 20	Male	21	91.7	68.7	80.2
32	do	2	14	6	Sept. 21	do	22	91.7	68.7	80.2
33	do	2	12	7	Sept. 20	Female	21	91.7	68.7	80.2
34	do	2	14	6	Sept. 21	Male	22	91.7	68.7	80.2
35	do	2	11	7	Sept. 19	do	20	91.5	68.5	80.0
36	do	2	11	7	do	Female	20	91.5	68.5	80.0
37	do	2	11	7	do	do	20	91.5	68.5	80.0
38	do	2	11	7	do	do	20	91.5	68.5	80.0
Average		1.9	9.9	6.8			18.6	93.7	71.9	82.8

LARVAL DEVELOPMENT

The rate of development of 38 larvae, reared during the summer of 1928, is recorded in Table 3. Larval life ranged from 6 to 14 days in length, and averaged about 10 days. Larvae are illustrated in Figures 5 and 6.

PUPATION

The average pupal period of 38 larvae (Table 3) was 6.8 days, with extremes of 5 and 11 days. Pupation usually takes place in the soil at depths up to 6 inches in sandy soil and at lesser depths in heavy soil. The writers have taken 517 pupae and 166 larvae from 1 quart of sandy soil removed from beneath the edge of a pile of infested cull figs. The pupa is shown in Figure 5.

LIFE CYCLE

The duration of the life cycle (the length of time from the deposition of eggs, through incubation, larval development, and the pupal or transformation period, to the emergence of the adult female and the deposition of her first eggs) is controlled chiefly by temperature. If winter intervenes the life cycle is measured by months, but in the hot weather during which figs are ripening the cycle is a matter of days.

The average period from egg to adult shown in Table 3 was 18.6 days, and if we add to this the average preoviposition period, 3.2 days, recorded in Table 1, the resulting life cycle becomes 21.8 days. In other words, a generation of dried-fruit beetles may develop about every three weeks in warm weather. The shortest egg-to-adult period (Table 3) was 14 days, and the shortest mating-to-egg-laying period (Table 1) was 1 day, giving a possible minimum life cycle of 15 days under the most favorable conditions.

From the foregoing discussion it becomes evident that we have to deal with a very prolific insect. Between the ripening of the first crop of Adriatic figs and the maturing of the second crop there is sufficient time for the completion of a generation of the beetle. The ability of the insect to build up its population to large numbers in a short time can hardly be questioned.

SEX RATIO

Captured dried-fruit beetles to the number of 1,869 were nearly equally divided as to sex. Forty-five per cent of them were males and 55 per cent females. The sexes may be distinguished by the presence of a small circular plate in the center of the lower surface of the last segment of the body of the male.

FOOD MATERIALS

In the discussion of overwintering, various foods of adults and larvae were mentioned. With the exception of watermelons, these food materials consist for the most part of accumulations of fermenting tree fruits and raisins. In the warm months such accumulations are important. Heaps of peach pits and of decaying oranges are especially favorable, and piles of fermenting raisin trash at packing plants are very attractive to the beetles. Peaches on the ground, especially when left in piles or wet with irrigation water, breed beetles. Nectarines are often attacked, and the writers have observed dried-fruit beetles eating through the skin of sound nectarines on the trees, where two fruits touched or where a leaf was in contact with a nectarine. The beetles may be found in tomatoes; and Phillips, Smith, and Smith (*32*) included rotting apples, cull grapefruit, old prunes, and plums in the food list of the dried-fruit beetle. As a rule, fresh and cull figs are the most important foods of the beetle from the standpoint of the fig grower.

DRIED-FRUIT BEETLES IN FIG PLANTINGS

The activities of dried-fruit beetles in orchards or borders of fig trees are not easy to observe. The beetles are sometimes seen on the outside of figs, both on the trees and on the ground, usually near the eye of the fig. The writers have never noticed them on the branches or foliage except in two or three cases where a leaf was close to or touching figs. General flights of the beetles have been observed late in hot afternoons, when the insects could be seen against the light of the low sun as they hovered over figs that lay thickly on the ground. At such times rapid flights from near the ground to near-by trees were observed. When a beetle alights on a fig it ordinarily enters the fruit immediately.

No activity on the part of dried-fruit beetles has been observed by the aid of a flashlight at night. The insects avoid bright light when feeding, but doubtless do considerable exploring for food during the daytime; the writers have seen them hovering over baited traps in bright, hot weather.

Most growers of Adriatic or Calimyrna figs have had the experience of squeezing ripe figs, with the result that from one to a dozen or more dried-fruit beetles leave the fig. Individual figs vary in attractiveness to beetles, and it is probable that the presence of a few beetles in a fig makes it more attractive to others than uninfested fruit.

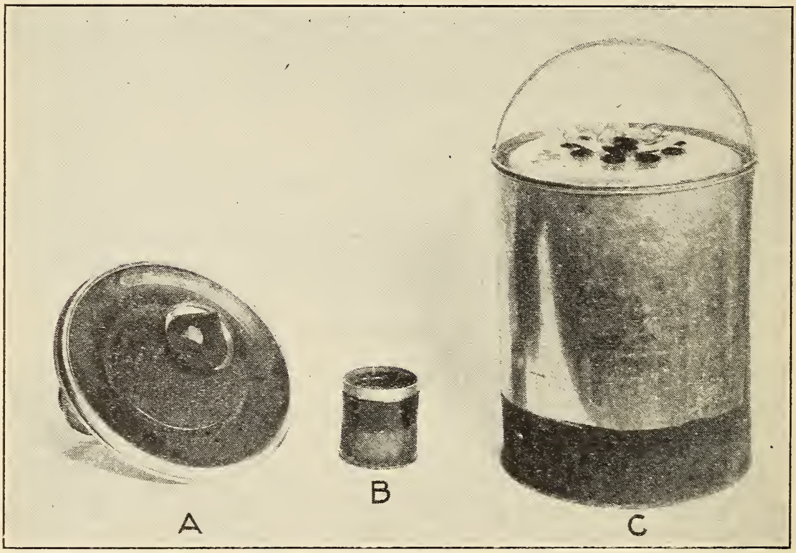

FIGURE 13.—Trap used in fig plantings in experimental trapping of dried-fruit beetles (*Carpophilus hemipterus*) and other insects which are attracted to fermenting fruit. The small tin can (B), part of the sides of which are of wire cloth, adheres by friction to the ring that is soldered to the wire-cloth cone on the lower side of the perforated cover (A). Insects are attracted into the trap by the odor of fermenting fruit in the large can (C) and enter the small can through the tip of the wire-cloth cone. In the illustration the lower part of the small can is filled with cotton in order to show the wire cloth which forms the lower half of the sides. The wire cloth allows the attractive odors to circulate readily beneath the tip of the cone. The flaps over the holes in the cover prevent trash from falling in and fouling the tip of the cone. About 2/15 linear scale

No definite information is available as to the distance the dried-fruit beetle can fly. It is apparent, however, that the large numbers of beetles that have been caught in traps before any figs were ripe were not all residents, so to speak, of the plantings where they were captured. To collect even a few dozen beetles in a fig orchard early in May would be quite impossible except by the use of baits. The natural conclusion is that most of the beetles attracted to traps at that time of the year are wanderers that come within range of the odors of the bait. How far they come has not been determined, but many of these long-lived, strong-flying insects probably travel several miles. The inferred spring-time wanderings of beetles apparently cease abruptly when fresh fruit appears throughout the San Joaquin Valley, and the beetle population may be thought of as becoming relatively fixed and concentrated in plantings where there is attractive food.

DISTRIBUTION OF THE DRIED-FRUIT BEETLE IN CENTRAL CALIFORNIA

In order to obtain information as to the species of insects concerned in the infestation of figs in orchards and borders, two methods have been employed—sampling orchard-run figs and trapping insects in fig orchards. Dried-fruit beetles were the insects most commonly found in the samples in 1927. In 1928 the distribution of this beetle, as shown by sampling, was about the same, although infestation was considerably more severe than in 1927.

A survey of insects in fig plantings was made in 1928 by distributing 37 traps on 18 ranches located along the distance from Modesto to Porterville. The trap used is illustrated in Figure 13. All the traps captured insects, the most of the species being the same as those found in figs. The largest catch per trap in one week, made during the first week of June, 1928, included 17,000 beetles of various species. The total catches were as follows:

Dried-fruit beetle (*Carpophilus hemipterus*)	279, 900
Miscellaneous beetles (mostly other species of the family Nitidulidae)	78, 200
Vinegar flies (various species of Drosophila)	2, 400
Miscellaneous insects	1, 700
Total	362, 200

The records of these catches are not actual counts, but were made by measuring the dried insects in a small container the approximate capacity of which was determined by counting several measured lots. The trapping shows that the dried-fruit beetle is present in all fig plantings, and may be caught in traps placed under fig trees anywhere in the San Joaquin Valley, with occasional exceptions, from early in March until late in October.

EXPERIMENTS AND SUGGESTIONS ON CONTROL

TRAPPING

In 1922 and 1923 (*32*) experimental control of smut and souring was attempted by the use of insect-tight cages over fig trees, by applications of various sprays, and by fertilization of the soil; all without success except for the very important result that no souring occurred on the caged trees, although all the neighboring trees contained an abundance of sour figs. In May, 1928, the writers began experiments in trapping to reduce the population of the dried-fruit beetle and other small beetles in fig plantings, and, since these experiments represent a new line of approach to the problem of reducing deterioration of the fig crop, they will be explained in some detail.

Two experiments on control were conducted, one with fig trees bordering on both sides an avenue 1,000 feet long, the other in an orchard. In both cases the variety of fig was the Adriatic. This variety was selected because (1) it comprises probably 75 per cent of the tonnage of dried white figs produced in California, and (2) it is severely attacked by insects and diseases.

In the experiment with the avenue of fig trees 29 traps were used. Each trap was baited with 3½ pounds of cull dried peaches moistened with 3 pints of water; the resulting spongy, slowly fermenting bait remained attractive to beetles for about four weeks. When the traps were put out, on April 30, they were placed on both sides of the avenue, one trap to three trees. The avenue extended in an east-west direction. In order to be exposed to sufficient heat to induce a satisfactory fermentation the traps were located on the southwest side of the trees, away from the shade of the foliage. After the weather became hot the traps were moved near the trunks of the trees to prevent too rapid drying of the bait. Preliminary trials in 1927 showed that baits on the ground attract more beetles than baits placed among the branches.

At the time the experiment was begun there was no ripe fruit in the San Joaquin Valley and few sources producing beetles. The beetles (all species) collected at the end of one week numbered 25,000; the second and third weeks' catches were about the same. After the first week in June, when the first crop of figs was ripening, the catches decreased abruptly and continued relatively small until the experiment was ended, on September 11. During the greater part of the harvest season the total weekly catches averaged about 3,000 beetles, most of which were species of Carpophilus and other Nitidulidae. Species other than *Carpophilus hemipterus* were plentiful. The season's total catch was as follows:

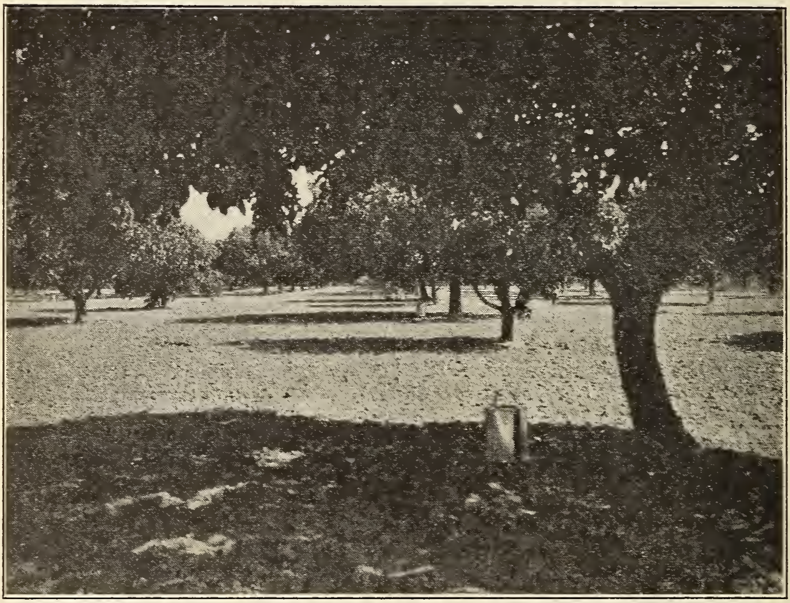

FIGURE 14.—Traps in operation in an experiment on control of the dried-fruit beetle (*Carpophilus hemipterus*) in an orchard of Adriatic figs. August 10, 1928

Dried-fruit beetles (*Carpophilus hemipterus*)	116, 700
Miscellaneous beetles (mostly other species of the family Nitidulidae	31, 800
Vinegar flies (species of Drosophila)	1, 500
Miscellaneous insects	1, 100
Total	151, 100

Samples of orchard-run figs were collected along the avenue at intervals of one or two weeks, and check samples were taken along an untrapped north-south avenue which intersected the trapped avenue at about its middle point. The results of the trapping were unsatisfactory so far as any beneficial effect on the crop in the trapped area was concerned. In spite of the fact that about 75,000 beetles were captured before the first crop was ripe, the figs of both the first and second crop became heavily infested, and the second crop soured badly.

In the experiment in the orchard (fig. 14) 34 traps were used in the central one-third of an orchard 8 acres in extent, distributed at the rate of one trap to four trees. As in the experiment with the avenue of fig trees, catches were large in May and dropped sharply early in June, when the figs began to ripen. Between crops there was a slight increase in the rate of catch, and another increase as the main crop drew to a close. (Fig. 15.) The total catches of different kinds of insects during the experiment (April 30 to September 22) were as follows:

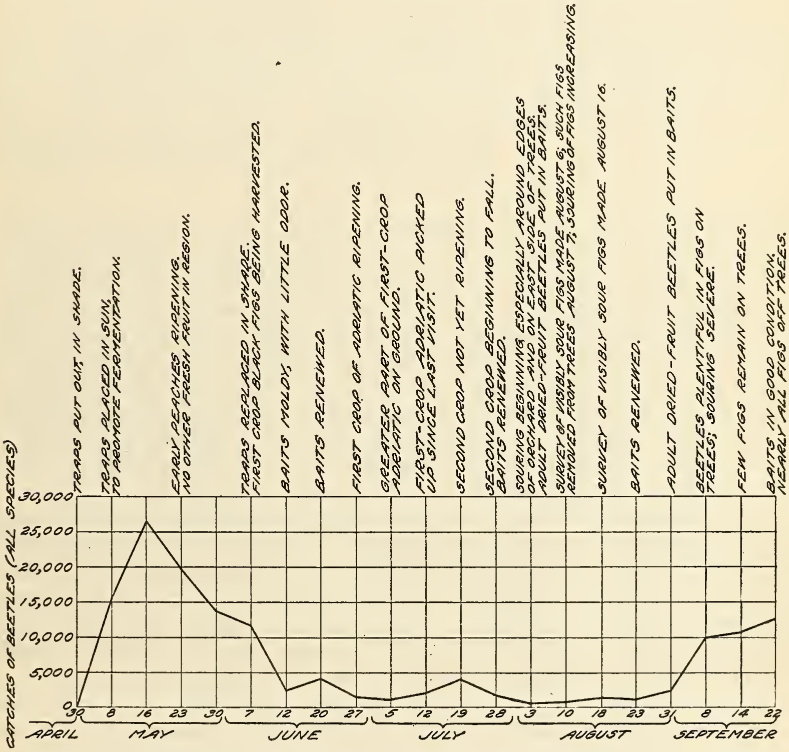

FIGURE 15.—Capture of beetles (all species) in 34 traps used in experiment on control of the dried-fruit beetle, in an orchard of Adriatic figs, with extracts from field notes. The ordinate for each date represents the total catch between that date and the one next preceding. The extracts from field notes relate to the corresponding dates

Dried-fruit beetles (*Carpophilus hemipterus*)	109, 700
Miscellaneous beetles (mostly other species of the family Nitidulidae)	33, 800
Vinegar flies (species of Drosophila)	700
Miscellaneous insects	800
Total	145, 000

Samples of figs taken from the ground at weekly intervals from both the trapped and untrapped portions of the orchard showed a definite and constant difference in favor of the crop in the trapped area as regards infestation and souring. The percentages of smut and molds were about the same in the trapped as in the untrapped portion. Subsequent experience in this orchard suggests that the trapped portion is normally more free from infestation and souring for reasons that are not apparent. No conclusion can therefore be expressed to the effect that the differences observed as between the trapped and untrapped areas were caused by the use of traps.

On August 16, when souring of the second crop of figs in the orchard was increasing rapidly, a survey of the orchard was made which consisted in recording all the visibly sour (dripping) figs on each tree. When the counts were combined to show the condition of the crop concentrically the totals were significant. If the outside row completely around the orchard be designated as row A, the next inside row as row B, and so on, the average number of sour figs per tree on each concentric row was: Row A, 8; row B, 6; row C, 3; row D, 3; row E, 3; and row F, 2.

The explanation for this distribution of the early souring—greatest on the outside and least on the trees in the center—would appear to be found in the probable behavior of beetles flying to the orchard. Most beetles would be expected to enter figs on the first trees they reached, whereas the smallest numbers would enter figs on trees farthest from the edges of the planting. The value of these observations lies in their suggestion that the most effective arrangement of traps might be around the edges of an orchard. In the case of borders or avenues, where all the trees are on the edge, so to speak, the individual trees are more exposed to the influx of wandering beetles than are the inside trees in an orchard.

The writers have made efforts to find baits more attractive than fermenting dried peaches, but without success. The following were tested separately, with negative results: Acetophenone, amyl acetate, amyl butyrate, benzaldehyde, benzyl alcohol, black-strap molasses, cinnamic alcohol, citronellol, ethyl alcohol, ethyl butyrate, ethyl phenyl acetate, geraniol, geranyl acetate, linalyl acetate, linalyl formate, linalool, methyl acetophenone, methyl phenyl acetate, oil of peach kernels, oil of sweet orange, and phenyl acetic acid. Moistened dried apricots did very well, but oranges molded too rapidly. Cull dried figs appeared to be too sour, did not produce a soft, spongy bait, and were not suited for competition with figs on the trees and on the ground. Baits containing too much water soured rapidly and were not attractive to dried-fruit beetles. The addition to peach baits of sodium benzoate or of sugar as preservatives was disadvantageous, and the attractive fermentation of the bait was likewise interfered with when tartar emetic, white arsenic, or sodium arsenite were added as poisons.

A satisfactory means of greatly increasing the attractiveness of the dried-peach bait was found to consist in infesting it with dried-fruit beetles. The observation was made repeatedly that unusually large catches of beetles were secured with baits that had become infested accidentally. In order to prevent the full-grown larvae from leaving the traps and pupating in the soil, the top 3 inches of the inside of the bait container was smeared with cup grease of high melting point.

In no case were larvae observed to escape from a trap so greased, and large numbers were killed by contact with the grease.

Smaller and less expensive containers than the traps used have several disadvantages. A small quantity of bait does not produce so powerful an attractive odor as larger quantities, and considerable odor is necessary during harvest in order to overcome with even partial success the attraction of the figs. Traps made of 2-quart Mason jars caught very few beetles. Five-quart lard pails, with perforated covers, containing moistened dried peaches, attracted many beetles in one cooperative experiment in which 100 of the pails were used, but the operation of this type of container apparently requires more attention than most growers could devote to the work. In the lard-pail experiment the infested bait was removed at intervals and put into a barrel partly filled with water, on the surface of which was a layer of an inch or so of waste crank-case oil. Before the pails were emptied the insects within were stupefied with a commercial fly spray in order to prevent their escape.

OTHER MEANS OF CONTROL

The first crop of dried figs is usually considered of little value, and is occasionally allowed to remain on the ground, to be picked up with the first picking of the main crop. Sometimes the first-crop figs on the ground are cultivated into the soil after irrigation between crops. Dried-fruit beetles, which can probably find little or nothing to eat in the spring, eagerly attack the ripe first-crop figs. Much breeding of beetles would probably be forestalled if these figs were picked up promptly, sold, or fed to stock, thoroughly dried, or burned.

Burial of cull figs is sometimes resorted to as a means of disposal, but this practice is ill-advised. The writers have observed the results of burial of cull figs on three ranches; in each instance the beetles escaped from the soil in large numbers. One grower buried in a vineyard, under about 1 foot of light sandy loam soil, several hundred pounds of cull figs heavily infested with larvae of the dried-fruit beetle. Profuse emergence of beetles resulted. On one occasion 172 exit holes were counted in 1 square foot of the soil. A trap was placed in the vineyard near the buried figs, and in 35 days in March and April 38,500 dried-fruit beetles and about 300 vinegar flies were taken.

At the laboratory 11 tests were made of the efficiency of burial of larvae and pupae of the dried-fruit beetle beneath various depths of light sandy loam soil. Five-inch stovepipes were used as containers, 100 insects being buried in each. Table 4 presents the results of the experiments.

TABLE 4.—*Results of 11 experiments, each with 100 insects, to test ability of adults of the dried-fruit beetle to develop and emerge from larvae and pupae buried at various depths in the soil*

Test No.	Stage of insect	Depth of burial	Adults emerging	Test No.	Stage of insect	Depth of burial	Adults emerging
		Inches	*Per cent*			*Inches*	*Per cent*
1	Pupae	8	34	7	Full-grown larvae	24	63
2	do	18	38	8	do	30	52
3	do	24	12	9	do	36	27
4	do	30	9	10	do	48	25
5	do	48	1	11	do	60	39
6	Full-grown larvae	12	83				

In the experiments with buried larvae (Table 4) some of the larvae escaped to the surface of the soil and reentered the soil before transforming to the pupal stage.

If cull figs are thoroughly dried in the sun and are subsequently protected from the rain very little breeding of beetles should result. The usual method of disposal is by feeding to stock or by sale. If peach pits are dried in the sun before being piled up, there will be no fermentation of the meat left on the pits, and no breeding of beetles. In fact, the piling of moist cull fruit is a practice that greatly favors the increase of dried-fruit beetles. Raisins held over on ranches are likely to breed beetles, especially if protection from the rain is neglected.

Parasites can not be depended upon to give relief from dried-fruit beetles. One species, recently described (*18*) as *Pseudisobrachium flavinervis* Fouts, a wasplike species new to science, was collected at night by the writers in 1927 near Lone Star, where it was actively searching about in soil in which cull figs infested with larvae and pupae of the dried-fruit beetle were buried. Another wasplike parasitic insect, a species of Blacus, was taken from cull figs infested with several insects, including the dried-fruit beetle, in the spring of 1928.

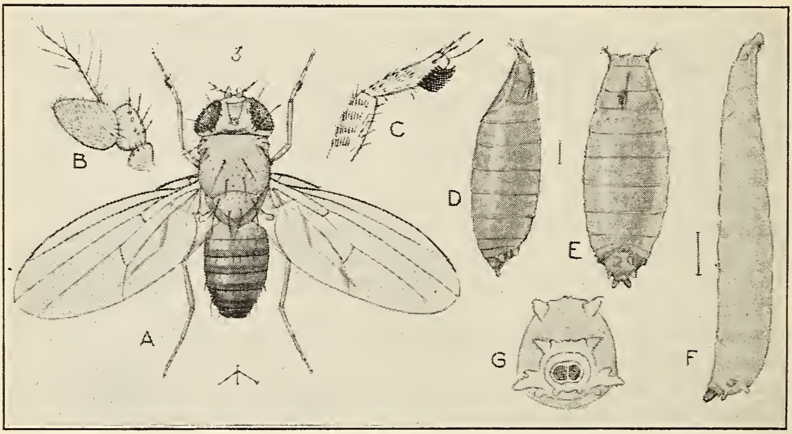

FIGURE 16.—*Drosophila ampelophila*, one of the vinegar flies: A, Adult; B and C, details of antenna and leg of adults; D and E, views of puparium, which incloses the pupa; F, full-grown larva; G, posterior extremity of larva. × 10. (Howard)

Frequent picking up of figs has been recommended as a measure calculated to decrease damage by insects. The fact that dried-fruit beetles frequently enter figs on the ground under the trees is well established, and it is reasonable to conclude that the shorter the period of exposure to the beetles the fewer in number will be the infested figs.

VINEGAR FLIES

Various species of the genus Drosophila, known as vinegar flies, or pomace flies, are often serious pests in fig orchards, especially in plantings of Adriatic figs where souring is in progress. *Drosophila ampelophila* Loew, which by some authorities is considered to be a synonym of *D. melanogaster* Meigen, appears to be the most common species in the San Joaquin Valley. These flies (figs. 5 and 16) are so common as hardly to require description. They are of cosmopolitan distribution.

Badly soured or split figs on the trees often contain large numbers of the flies, which may sometimes be so numerous as to congregate on the leaves near such figs. Heaps of fermenting fruit of all kinds harbor these insects. The larvae are of frequent occurrence in ripening and partially dried figs, where they may be mistaken for the larvae of the dried-fruit beetle, which they resemble in color. The larvae of the latter, however, are provided with legs and eyes and are broad at both ends, whereas the larvae of the vinegar fly are legless, eyeless maggots, pointed at the head end. The puparia, or pupal cases, of the vinegar fly are peculiar in that they bear a conspicuous pair of "horns" on the anterior end, and the eggs also are provided with a pair of filaments.

Vinegar flies usually do not become noticeably plentiful in fig plantings until toward the end of August, and the period of greatest abundance occurs a month or more later. The writers have collected larvae in an Adriatic fig as early as July 31.

It seems probable that, for the most part, vinegar flies are attracted to and breed in figs on the trees, after the figs have become sour through the agency of dried-fruit beetles. In other words, fermentation may perhaps be regarded as in many cases the cause of infestation by Drosophila, rather than as the result of the presence of the insects. However, there are times when the flies become so abundant that they appear to "overflow" from sour figs into sound figs. B. J. Howard has found vinegar flies in figs in which no multiplication of yeasts was apparent, a circumstance indicating that the insects may enter figs that show no signs of fermentation. Workers who have reared Drosophila under carefully controlled conditions have found that the larvae feed principally on the yeast in the fermenting media in which they are reared. Baumberger (*3*) found that the adults, however, "do not require proteins but survive for a much longer period on sugar agar than upon yeast agar."

Examination, made at the dried-fruit insect laboratory, of large numbers of infested figs from deliveries of sorted figs in 1927 and 1928 showed that the Mission, Kadota, and Calimyrna varieties were practically free from any stages of Drosophila, whereas the Adriatic variety was well infested with the larvae, pupae, and adults. This condition is shown in Tables 6 and 15.

The elimination of breeding places, such as piles of fruit pits or decaying cull fruit, should be helpful in keeping down the population of the vinegar fly, as well as that of the dried-fruit beetle.

Although species of Drosophila have been used more extensively in experimental genetics than have any other insects, and although mention of these flies is usually made in publications dealing with flies commonly found in and about dwellings, a very little life-history work of the type usually done when economically important insects are studied has been recorded. This may be the case partly because the flies have been regarded more as nuisances than as pests. They are an abomination in certain food industries, but their rôle as enemies of figs appears to be one of the few cases in which they are directly injurious to a growing crop.

The writers are indebted to Lutz (*27*) for the following information on the life history of *Drosophila ampelophila:*

The eggs are laid near the surface of fermenting material, a pair of filaments on the egg protruding above the surface. The eggs sometimes hatch while still within the body of the female, but this occurrence is unusual unless no suitable material in which to oviposit has been found. Hatching ordinarily takes place probably less than 30 hours after the eggs are laid, the maximum time being about 50 hours.

The larvae usually feed near the surface of the fermenting mass, and the length of larval development, which depends largely upon temperature and food and therefore varies greatly, is suggested by the data in Table 5, which also illustrate the range in duration of the pupal period. The data give the result of an experiment by the writer named, involving about 4,000 flies fed on banana and kept at a temperature of about 77° F., and show the number of individuals completing the periods named in the corresponding number of days.

TABLE 5.—*Record of an experiment on the development of Drosophila ampelophila, fed on banana and kept at a temperature of about 77° F.; numbers completing egg-larval period and numbers completing pupal period in specified number of days*

Days	Number completing egg-larval period	Number completing pupal period	Days	Number completing egg-pupal period	Number completing pupal period
2		1	8	405	9
3		3	9	91	6
4	92	1,087	10	14	0
5	1,258	2,398	11	4	2
6	1,435	438	12		1
7	744	33			

In order to pupate, the larvae crawl to the drier portions of the food or even entirely out of it. The horns of the pupal case protrude into the air if pupation takes place in the food.

Mating activity begins the second day after the perfect fly emerges from the pupal case. The females mate more than once. The length of adult life depends largely upon the environment. Of 267 unmated females, only 1 lived to be 80 days old, and the average longevity was 26. 4 days. The average length of life of flies furnished water but no food, and kept at a relatively constant temperature of 68°F., was 67½ hours. When given neither food nor water, at the same temperature, the female flies lived an average of 56 hours and the males 53.5 hours.

Some interesting records obtained during the breeding of *Drosophila ampelophila* on banana have been published by Hyde (*25*). The average egg-laying capacity of hundreds of females was about 500 eggs, and the length of their lives about 40 days. The most prolific fly observed by Hyde laid 2,184 eggs, and two others laid 1,807 and 1,613 eggs, respectively. The first individual on an average produced her own weight of eggs every two days, and often produced that weight in 24 hours. Unmated females laid regularly, and apparently the number of eggs produced was not modified by mating.

When certain phases of the life history of *D. ampelophila* are compared with the corresponding facts in the life history of the dried-fruit beetle, it is seen that the former lays about half as many eggs as the latter, but develops about twice as rapidly.

THE SMALL DARKLING BEETLE

The small darkling beetle, identified by F. E. Blaisdell as *Blapstinus fuliginosus* Casey, is ordinarily a ground-inhabiting species, although the same or a similar species has been reported to the writers as having injured ripe figs on the tree. The typical habitat of this dull-black beetle is among the clods of soil, under which it may frequently be found. Attempts by the writers to induce it to fly were unsuccessful.

Very little is known of the life history of the small darkling beetle. The name "false wireworms" has been applied to the larvae of the family Tenebrionidae, to which this insect belongs. The larvae of the present species presumably feed on vegetable materials in the soil.

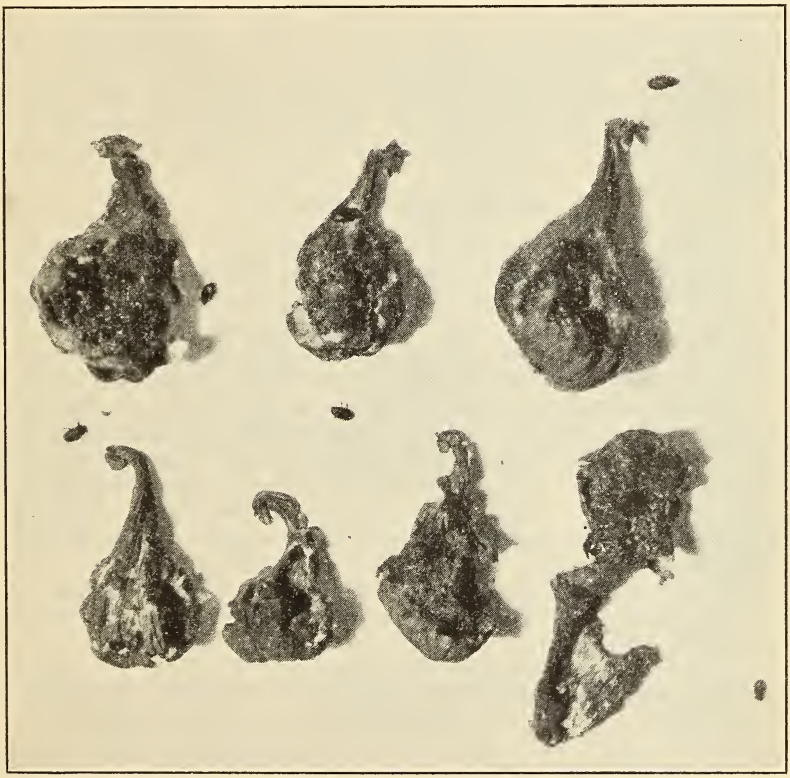

FIGURE 17.—The small darkling beetle (*Blapstinus fuliginosus*) and its work on first-crop Calimyrna figs. × ½

The adults may be found in fig orchards during most of the year, but are most numerous, as a rule, during July and August. When they are abundant the beetles cluster in large numbers on and under fallen figs of the first crop and the early part of the second crop, riddling them as shown in Figure 17. Less extensive injury is quite common and is especially noticeable on Mission figs, the light color of the areas fed upon showing in sharp contrast with the dark skin of this fig. According to I. J. Condit, these beetles have caused some injury by girdling suckers at or near the surface of the ground.

The use of poisoned mash is said to have given some control, but according to the writers' information and observations the results have not been very satisfactory. Experiments by growers with variations of the following grasshopper mash (*16, p. 73*) are suggested:

Bran or middlings	25 pounds.
Blackstrap molasses	2 quarts.
White arsenic, sodium arsenite, or Paris green	1 pound.
Water to make a thin mash.	

Thoroughly mix the bran and poison while dry. Dilute the molasses in 1 or 2 gallons of water and add while stirring the poisoned bran, then add more water until a thin mash is secured.

Chopped fruit may be added to the mash. Alfalfa meal is reported to have been used successfully in place of bran in the mash, and one grower found that fresh grapes were attractive to the beetles.

The general observations of the writers during 1927 and 1928 indicate that the population of small darkling beetles decreases markedly during the dry, hot weather that follows the peak of abundance in July.

MISCELLANEOUS INSECTS

Dead ants are occasionally found in dried figs. The writers have observed ants on figs on the trees, where they were attracted to the froth exuding from souring fruit. Although they are objectionable when present in figs, they may be somewhat beneficial, as they feed to some extent on the larvae and pupae of the dried-fruit beetle.

Small insects of a score or more species have been taken by the writers from samples of figs collected on ranches. Most of them are of infrequent occurrence. A few specimens of the lead-cable borer (*Scobicia declivis* Lec.) have been recorded, and *Notoxus calcaratus* Horn and *Cathartus advena* (Waltl.), the "foreign grain beetle," are occasionally found. Aside from the insects considered in detail in this circular, by far the most common are various species of beetles of the genus Carpophilus and *Epuraea luteola* Erich.

After cull figs have become partially decayed they are inhabited by a number of scavenger insects, including the larvae of a large 2-winged fly, identified by F. R. Cole as *Hermetia illucens* L.

DEATH OF FIG INSECTS FROM INCIDENTAL CAUSES PREVIOUS TO STORAGE

Insects are not infrequently found dead in sour figs in the orchard. In cases of this kind the eye of the fig is usually found to have been tightly sealed by the exudation of fermented juice. The death of the insects appears to be due to lack of oxygen, since the cavity of the fig is probably filled with the carbon dioxide which is evolved during the fermentation of the sugars in the pulp. Sealed sour figs, especially Adriatic, which are strongly inflated by the pressure of the inclosed gases are often seen.

Soon after they are picked up, Adriatic figs are usually put into sulphur houses (fig. 31) for bleaching by the fumes of burning sulphur. The strength of the gas and the duration of exposure doubtless vary a good deal, and although the writers have made no tests of the insect killing that takes place when infested figs are sulphured, it is fair to suppose that some insects are killed. The sulphur houses are not air-tight, because the admission of air is required in order to burn the sulphur. Parker (*31*) exposed black figs heavily infested with the dried-fruit beetle to the fumes of burning sulphur in a sulphur box and found that all the insects were killed. Twenty-five eggs of the Indian-meal moth were treated in the same way, with the result that the eggs failed to hatch.

Nearly all figs are dried in a single layer on trays laid on the bare ground of drying yards and are exposed to the direct heat of the sun, although a few growers dry their crops in the shade. The sun drying usually continues one to three days and frequently for longer periods. It goes without saying that some insects are killed in the figs on the drying trays. Probably part of them leave the figs and escape to the shaded soil beneath the trays, although the writers have failed to find evidence of this in drying yards. Judging from the behavior of dried-fruit beetles in samples of figs brought to the laboratory in paper bags, it is probable that many of the insects leave the figs during the picking up of the fruit and the dropping of it into buckets, the emptying of the buckets into picking boxes, and the hauling of the boxes to the drying yards.

In connection with a consideration of the effect of the sun's heat on insects within figs on drying trays, it is a matter of interest that the fig harvest begins after the hottest weather has passed. Harvest commences late in July or early in August, but much of the crop of dried figs usually is harvested after the beginning of September. July is the hottest month at Fresno, with a mean maximum temperature for 35 years of 99.1° F. The mean maximum for August is 97.6°, and for September 89.1° (*40, p. 30*).

The following miscellaneous observations were made in August and September, 1929, and are included here not because they are in any sense conclusive but because no other information of the sort is available.

On each of nine days in the last half of August, 100 eggs of the dried-fruit beetle were placed within figs on a drying tray exposed to direct sunshine. The length of exposure ranged from three to seven days, and the maximum temperatures recorded within figs on the same tray during the exposures ranged from 126.5° to 131° F. All of the eggs failed to hatch, whereas the average hatch of 412 eggs kept as controls under favorable conditions in the laboratory was about 96 per cent. Nine per cent of the eggs exposed for four days early in September to temperatures which reached 120.2° within the figs hatched.

About 30 young larvae of the dried-fruit beetle were placed within a fig on each of five days during the last half of August. The larvae were from 1 to 3 days old. Exposure of each lot for periods of three or four days to maximum temperatures which ranged from 126.5° to 131° F. within the fruit resulted in complete mortality of the 154 larvae. Early in September, the survival of larvae which were exposed for three days and which experienced a maximum of 123.8°, was 20 per cent; 45 per cent of other larvae which were exposed for one day to temperatures which reached 116.6° within the figs survived.

The temperatures within figs on the drying trays were recorded five times a day—at 9 and 11 a. m., and at 1, 3, and 5 p. m. The bulb of each thermometer was inserted through the eye of a fig, the stem of the instrument being shaded.

Table 6 presents a summary of results of examinations of 958 infested figs, which were taken from samples of growers' deliveries in the interval from October 13 to October 29, 1927, and will suggest the extent to which incidental causes bring about the death of fig insects before the fruit is delivered to packing houses. The parasite Habrobracon accounts for the death of some of the larvae of the Indian-meal moth and the fig moth, and it is possible that some insects recorded in the table as dead were crushed within the tightly pressed figs in the sweat boxes.

TABLE 6.—*Summary of results of examinations of insect-infested figs from samples of growers' deliveries, October 13–29, 1927*

Number of figs infested	Kinds of insects in figs	Observed details of infestation								
		Feeding by insect	Larvae		Pupae		Pupal cases	Adults		Total observations
			Living	Dead	Living	Dead		Living	Dead	
	ADRIATIC FIGS									
401	Dried-fruit beetle	88	25	10	1	1	------	2	17	144
	Vinegar fly	------	------	1	------	4	12	------	6	23
	Small darkling beetle	------	------	------	------	------	------	------	6	6
	Indian-meal moth	125	42	43	9	------	12	------	------	231
	Fig moth	------	1	3	------	------	------	------	------	4
	Parasite of moth larvae	------	2	1	6	1	9	4	------	23
	Total	213	70	58	16	6	33	6	29	431
	MISSION FIGS									
376	Dried-fruit beetle	60	32	1	------	------	------	1	------	94
	Vinegar fly	------	------	------	------	------	------	------	------	0
	Small darkling beetle	------	------	------	------	------	------	------	------	0
	Indian-meal moth	128	84	44	5	1	7	------	------	269
	Fig moth	------	3	1	------	------	------	------	------	4
	Parasite of moth larvae	------	4	------	4	------	5	------	1	14
	Total	188	123	46	9	1	12	1	1	381
	CALIMYRNA FIGS									
181	Dried-fruit beetle	37	38	4	------	1	------	------	1	81
	Vinegar fly	------	------	------	------	1	2	------	------	3
	Small darkling beetle	------	------	------	------	------	------	4	4	8
	Indian-meal moth	40	30	15	8	------	3	------	------	96
	Fig moth	------	2	------	------	------	------	------	------	2
	Parasite of moth larvae	------	2	------	1	------	------	------	------	3
	Total	77	72	19	9	2	5	4	5	193
	Grand total	478	265	123	34	9	50	11	35	1,005

Table 6 presents separately the indications of infestation found in the three kinds of figs, Adriatic, Mission, and Calimyrna. For instance, the data under Mission Figs show the conditions observed in 376 infested figs. A fig showing more than one type of infestation is recorded under more than one box head, giving 381 records for 376 figs. The number of individual insects present, in whatever stage, was not recorded. The box heads are self-explanatory, except that Feeding by Insect refers to evidence found that the figs concerned had been fed on by the insect designated.

The insects observed for which records were made are six in number—the dried-fruit beetle, *Carpophilus hemipterus*, the vinegar fly, including a number of species of Drosophila, the small darkling beetle, *Blapstinus fuliginosus*, the Indian-meal moth, *Plodia interpunctella*, the fig moth, *Ephestia cautella*, and Habrobracon, a parasite of the larvae of the two moths named. Besides these, several small beetles were found. All pupal cases, pupae, and feeding of the Indian-meal moth and the fig moth were recorded under the Indian-meal moth. The larvae and pupae designated as those of the dried-fruit beetle probably included a few other species of the family Nitidulidae.

INSECTS ATTACKING WELL-DRIED, HARVESTED FIGS

Properly dried figs,[4] free from smut and souring, probably do not develop those troubles in storage, and such fruit is hardly a suitable medium for the increase of dried-fruit beetles or vinegar flies. The insect pests of stored figs, however, find the dried product much to their liking, and, when allowed access to it, they bring about a rapid reduction in its quality. The pests of figs in storage are discussed in the pages following, and methods for controlling them are outlined on pages 53 to 56.

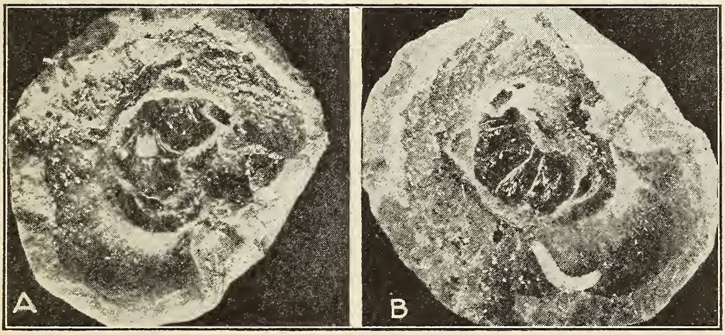

FIGURE 18.—The Indian-meal moth (*Plodia interpunctella*) on dried apricots: A, Adult; B, larva. Natural size. (Parker)

THE INDIAN-MEAL MOTH

The Indian-meal moth (*Plodia interpunctella* Hbn.) is a very general feeder on vegetable products, and has been carried by commerce to all parts of the world. Among the many foods of the larvae are listed dried fruits of all kinds, nuts, corn meal, flour, cereals, chickpeas, table beans, peanuts, and chocolate. The adults of this and the other moth pests of dried fruits take no food.

The moths vary in size and in coloration. They ordinarily measure from one-half to three-fourths of an inch across the expanded wings. The outer two-thirds of the fore wings is reddish brown; in the center is a band of a coppery luster, while the inner or basal third is dark gray. When the moth is at rest the wings are folded horizontally along the body. (Fig. 18.)

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[4] According to several moisture determinations made by C. D. Fisher, of the Dried Fruit Association of California, dried figs ordinarily contain between 14 and 19 per cent of water. Christie and Woodworth (*6*) found 18 per cent moisture in dried apricots and prunes to be optimum for insect development as shown by the combined results obtained with the Indian-meal moth and saw-toothed grain beetle.

The moths are usually found in dark places where dried figs and other dried fruits are stored. The females have a tendency to remain on or near the fruit during the period of egg laying, while the males fly about more actively, in search of females. The moths are chiefly night fliers and fly readily when disturbed, moving with a zigzag flight. The length of life of the moths varies with the season of the year, ranging from 2 or 3 days in hot weather to 30 days during the cooler weather of spring and fall.

The eggs of the Indian-meal moth are minute, but may be detected on the surface of dried figs with the unaided eye. They are opaque-white, with a slight luster, are laid singly or in small clusters, and usually are attached to the figs. Occasionally eggs are found inside a dried fig which has an open eye. The eggs hatch in from 2 to 4 days in summer, but the time required for hatching may range from 6 to 14 days in cooler weather.

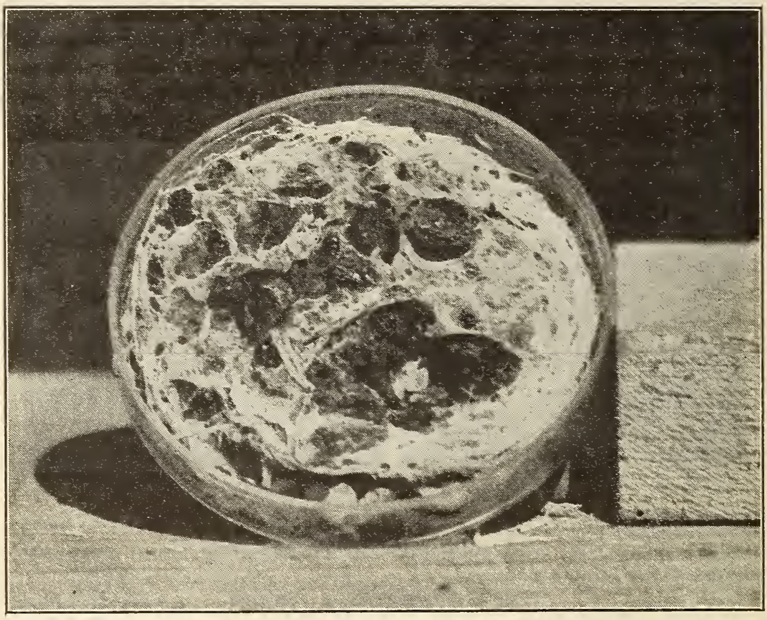

FIGURE 19.—Webbing by larvae of the Indian-meal moth (*Plodia interpunctella*) on raisins. × ⅔

There is much variation in the size of larvae of the Indian-meal moth. When fully grown (fig. 18) they range in length from three-eighths to three-fourths inch; the average length is about one-half inch. The larvae are dirty white, yellowish, pinkish, or greenish, and frequently exhibit traces of two or more of these colors.

Usually the newly hatched larvae begin feeding inside of the fig. They often seclude themselves among the flowers lining the cavity of the fruit, and no signs of webbing (fig. 19) are seen for a few days. By the time the larvae are 1 week old they have constructed a small cocoonlike structure, made of pellets of their excrement webbed together. The full-grown larvae frequently migrate out of the figs in order to spin cocoons (fig. 20) for pupation, and it is during this migration that they are most in evidence. The larvae may reach maturity in 21 days in June, July, and August, but there is much variation in the duration of the larval period.

The Indian-meal moth passes the winter in the larval stage, and the overwintering individuals may remain in that stage for five to eight months in the San Joaquin Valley, in unheated buildings. In heated buildings the feeding and growth of larvae continue during the winter.

The pupae are light brown, changing to a darker brown with age. They are usually inclosed in silken cocoons spun by the larvae, and range from four-sixteenths to seven-sixteenths of an inch in length.

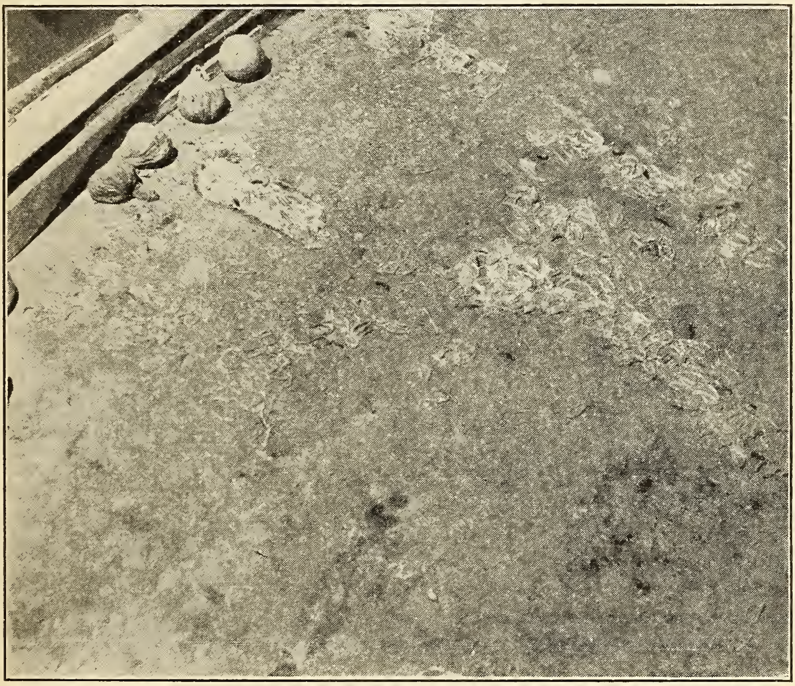

FIGURE 20.—Overwintering cocoons spun by well-grown larvae of the Indian-meal moth (*Plodia interpunctella*) on a concrete floor under boxes of dried figs. February 18, 1927

The pupal period occupies from 4 to 8 days in hot summer weather, but in cool weather this stage may last 30 days.

Table 7 gives, in condensed form, information on the life history of the Indian-meal moth. Indian-meal moths (fall adults), newly emerged, were mated in the fall of 1925, and a record of their oviposition, longevity, etc., was kept. Six hundred of their progeny were carried through the winter. The larvae transformed to pupae in the spring of 1926, and the first adults (spring adults) which emerged from these pupae were mated, and the details of their activities were recorded. Their progeny developed to the adult stage (first generation), and the process was repeated until cold weather. No adults resulted from the fifth generation until the spring of 1927, and some of the larvae of the third, and many of the fourth, generation likewise did not become adult until early in the following year. Adults which resulted from overwintered larvae of the last three generations of 1926 would be considered the spring adults of 1927.

TABLE 7.—*Summary of studies of the life history of the Indian-meal moth on dried fruits, at Fresno, Calif.*

Designation	Insects		Average preoviposition period	Average oviposition period	Average postoviposition period	Average longevity		Eggs laid	
	Male	Female				Males	Females	Total	Average per female
	Number	*Number*	*Days*	*Days*	*Days*	*Days*	*Days*	*Number*	*Number*
Fall adults	20	20	1.6	9.5	4.0	13.5	15.0	3,106	155.3
Spring adults	14	14	2.9	7.6	.9	18.8	11.6	2,368	169.1
First generation	11	11	.5	3.5	1.6	6.6	5.6	1,428	129.8
Second generation	11	14	.6	3.6	1.3	4.8	5.7	1,558	111.3
Third generation	10	23	.9	6.3	2.5	9.3	9.7	3,979	173.4
Fourth generation	3	7	1.6	10.4	4.4	14.7	16.4	1,371	195.9
Total or average	69	89	1.3	6.8	2.4	11.3	10.7	13,810	155.8

Designation	Insects		Average mean incubation period	Average percentage of hatch	Developmental period, egg to adult			Dates, inclusive
	Male	Female			Maximum	Minimum	Average	
	Number	*Number*	*Days*	*Per cent*	*Days*	*Days*	*Days*	
Fall adults	20	20	10.7	61.0	------	------	------	Sept. 17 to Nov. 30, 1925
Spring adults	14	14	8.2	79.3	------	------	------	Mar. 30 to Apr. 22, 1926.
First generation	11	11	4.9	71.5	65	37	49.3	Apr. 4 to June 21, 1926
Second generation	11	14	4.1	71.9	72	33	47.4	June 8 to Sept. 2, 1926.
Third generation	10	23	5.7	73.7	302	36	63.6	July 10, 1926, to May 9, 1927.
Fourth generation	3	7	8.3	59.8	288	52	204.0	Aug. 17, 1926, to June 1, 1927.
Fifth generation	------	------	------	------	213	196	201.3	Oct. 10, 1926, to May 11, 1927.
Total or average	69	89	7.0	69.5	------	------	------	------

The generations, as given in detail in Table 7, show an uneven rate of development, and after about August 1 they become mixed in infested dried figs. The spring moths in unheated storage houses may include individuals of the third, fourth, and fifth generations of the preceding year. The peak of emergence of spring adults occurs at Fresno in April.

THE FIG MOTH

The fig moth (*Ephestia cautella* Walk.) was present in dried figs delivered by growers to packing houses in larger numbers in 1928 than in 1927. It appeared in 1928, for the first time, as an important pest of raisins in the San Joaquin Valley. The moth (fig. 21) is of approximately the same size as the Indian-meal moth, and the larvae of the two insects have similar habits. Among the materials eaten by the larvae of this insect are dried fruits, nuts, rice, peanuts, cocoa beans, corn meal, cereal foods, cottonseed, cottonseed meal, linseed meal, and flour.

A discussion of the fig moth as a pest of stored products in the United States, by Chittenden (*5*), and a Report on the Fig Moth in Smyrna, by Smyth (*38*), in which mention is made also of the dried-fruit beetle in fig orchards near Smyrna, were published in 1911 as a single bulletin. A portion of the following description of the stages of the fig moth has been taken from the part first mentioned.

The adult is more slender than the Indian-meal moth and not so prominently marked. The color of the fore wings varies, most individuals being mottled gray, while others are strongly suffused with fawn-colored scales. The moths fly with a quick dart and rapid vibration of the wings.

In Table 8 are given the life-history records of seven mated pairs of the fig moth.

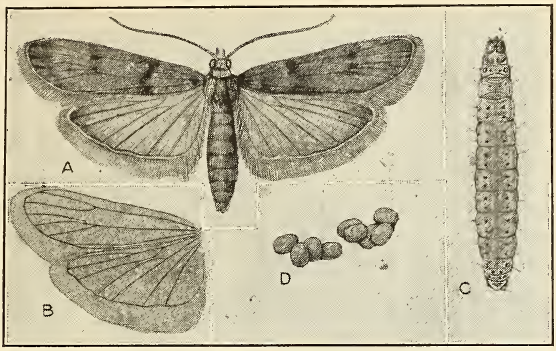

FIGURE 21.—The fig moth (*Ephestia cautella*); A, Adult; B, details of wing; C, full-grown larva; D, two egg masses. (Chittenden and Smyth.) A, B, C, × 3; D, × 7.8.

TABLE 8.—*Data on the life history of seven mated pairs of the fig moth (Ephestia cautella) at Fresno, Calif., in 1927*

Pair No.	Date of emergence		Preoviposition period	Oviposition period	Post-oviposition period	Longevity		Total eggs laid	Incubation period			Average mean temperature during life of female
	Male	Female				Male	Female		Maximum	Minimum	Average	
			Days	*Days*	*Days*	*Days*	*Days*		*Days*	*Days*	*Days*	° *F.*
1	May 4	May 4	1	4	2	[1]	7	123	9	7	7.8	69.5
2	July 20	July 21	3	4	0	7	7	105	7	3	5.0	91.1
3	July 22	July 22	2	12	1	6	15	207	8	4	5.3	88.7
4	(?)	July 26	1	8	2	15	11	156	------	------	------	86.9
5	July 28	July 29	0	8	0	11	8	72	8	4	5.7	86.9
6	July 25	do	2	6	0	8	8	98	------	------	------	87.6
7	July 31	July 31	0	6	4	10	10	38	------	------	------	87.3
Average			1.3	6.9	1.3	9.5	9.4	114.1	8	4.5	5.9	--------

[1] Escaped.

The eggs of the fig moth are whitish when first laid, turning a somewhat brownish color before hatching. They are rather loosely attached to the fruit and frequently fall from the surface when the fruit is handled. Hatching occurs in from four to eight days during summer weather at Fresno.

The larvae (fig. 21) are white in color when newly hatched, and about 1 millimeter long. They feed inside the fig, and by the time their growth is completed conspicuous webbing is usually in evidence. The dirty-white color of the full-grown larva is tinged with brown or purple, and there are several rows of prominent dots along the back, giving the larva a distinctly striped appearance. The larvae are of about the same average size as the larvae of the Indian-meal moth. When fully grown they usually migrate out of the figs for pupation. It is during this migration that the insect is most frequently seen.

Table 9 presents the developmental periods of 17 fig moths bred on raisins at Fresno, with related information. It may be seen that in hot weather at Fresno the pupal period ranged from 9 to 17 days.

TABLE 9.—*Data on the development of 17 fig moths (Ephestia cautella) reared on raisins, at Fresno, Calif., 1927*

Rearing No.	Date egg laid	Incubation period	Larval period	Pupal period	Date adult emerged	Developmental period, egg to adult	Sex	Temperature, egg-to-adult period		
								Mean maximum	Mean minimum	Mean
		Days	*Days*	*Days*		*Days*		° *F.*	° *F.*	° *F.*
1	May 6	8	49	10	July 12	67	Male	84.4	67.6	78.5
2	do	8	52	10	July 15	70	do	89.6	68.2	78.9
3	do	8	57	9	July 19	74	do	90.4	68.6	79.5
4	do	8	59	9	July 21	76	Female	90.7	68.9	79.8
5	do	8	59	10	July 22	77	do	90.8	69.0	79.9
6	do	8	59	10	do	77	do	90.8	69.0	79.9
7	do	8	62	10	July 25	80	Male	91.3	69.5	80.4
8	do	8	64	9	July 26	81	Female	91.4	69.6	80.5
9	do	8	58	17	July 28	83	Male	91.6	69.9	80.7
10	do	8	67	9	July 29	84	Female	91.7	70.0	80.8
11	do	8	66	10	do	84	do	91.7	70.0	80.8
12	do	8	67	10	July 30	85	Male	91.8	70.1	80.9
13	do	8	68	10	July 31	86	do	91.9	70.2	81.0
14	do	8	67	11	do	86	Female	91.9	70.2	81.0
15	do	8	73	10	Aug. 5	91	do	92.1	70.4	81.2
16	do	8	74	10	Aug. 6	92	do	92.2	70.4	81.3
17	do	8	80	12	Aug. 14	100	Male	92.7	71.0	81.8
Average		8	63.6	10.4		81.9				

The cocoons inclosing the pupae are often spun in the cracks of dried-fruit boxes, and sometimes inside figs near the eye.

THE DRIED-FRUIT MOTH

Small numbers of the dried-fruit moth (*Vitula serratilineella* Rag.) have since 1925 been collected by the writers in the San Joaquin and Santa Clara Valleys from stored figs, raisins, and prunes. The insect was first reported as a pest in California in 1903 (*12*), when it was found infesting dried fruit received by the United States Department of Agriculture from Santa Clara County, Calif. In 1927 Hamlin and Reed (*20*) reported briefly on the life cycle of the insect at Fresno.

The adults are mottled-gray moths nearly twice as large as the Indian-meal moth. They are likely to be found in the dark corners of storage bins of dried fruit or between rows of stacked boxes.

Records of the activities of seven mated pairs of the dried-fruit moth are given in Table 10.

TABLE 10.—*Data on the life history of seven mated pairs of the dried-fruit moth (Vitula serratilineella) at Fresno, Calif., 1927*

Pair No.	Date of emergence		Preoviposition period	Oviposition period	Post-oviposition period	Longevity		Total eggs laid	Average mean temperature during life of female
	Male	Female				Male	Female		
			Days	*Days*	*Days*	*Days*	*Days*		° *F.*
1	June 15	June 15	2	5	1	(1)	8	164	85.3
2	June 17	June 18	9	1	1	9	11	63	81.4
3	June 24	June 24	1	3	0	8	4	67	78.4
4	June 26	June 26	1	11	1	9	13	200	83.1
5	June 30	June 27	4	5	0	5	9	114	83.2
6	do	June 29	2	5	0	9	7	116	85.2
7	July 1	July 1	1	9	1	14	11	172	85.7
Average			2.9	5.6	.6	9	9	128	

[1] Escaped.

The females recorded in Table 10 were supplied with Sultanina (Thompson Seedless) raisins on which to lay their eggs. The longevity of the females ranged from 4 to 13 days, the average being 9 days. The total number of eggs laid ranged from 63 to 200, with an average of 128.

Records of the developmental periods of the dried-fruit moth are given in Table 11.

TABLE 11.—*Data on the development of 43 dried-fruit moths* (*Vitula serratilineella*) *on raisins, at Fresno, Calif., 1927*

Rearing No.	Date egg laid	Incubation period	Larval period	Pupal period	Date adult emerged	Period, egg to adult	Sex	Temperature, egg-to-adult period		
								Mean maximum	Mean minimum	Mean
		Days	*Days*	*Days*		*Days*		°*F.*	°*F.*	°*F.*
1	Mar. 30	10	53	10	June 11	73	Male	81.3	58.7	70.0
2	do	10	54	9	do	73	Female	81.3	58.7	70.0
3	do	10	52	12	June 12	74	Male	81.4	58.8	70.1
4	do	10	56	10	June 14	76	Female	82.0	59.1	70.5
5	do	10	56	11	June 15	77	do	82.2	59.4	70.8
6	Mar. 29	11	59	8	do	78	Male	81.6	60.6	71.1
7	do	11	57	10	do	78	do	81.6	60.6	71.1
8	Mar. 30	10	60	8	June 16	78	do	82.3	60.9	71.6
9	Mar. 31	10	58	10	June 17	78	do	81.5	61.2	71.3
10	do	10	58	10	do	78	do	81.5	61.2	71.3
11	Mar. 30	10	62	9	June 19	81	Female	82.8	60.2	71.5
12	Mar. 31	10	65	8	June 22	83	do	82.6	61.9	72.2
13	Mar. 29	11	66	8	do	85	do	83.1	61.7	72.4
14	Mar. 30	10	67	8	June 23	85	do	83.4	60.7	72.0
15	Mar. 29	11	67	8	do	86	do	83.2	61.8	72.5
16	Mar. 30	10	68	8	June 24	86	do	83.5	60.9	72.2
17	Mar. 29	11	66	10	do	87	Male	83.4	62.0	72.7
18	Mar. 30	10	68	9	June 25	87	Female	83.5	61.1	72.3
19	Mar. 31	10	69	8	June 26	87	do	82.7	62.4	72.5
20	Mar. 30	10	70	8	do	88	Male	83.6	61.2	72.4
21	Mar. 29	11	70	9	June 27	90	Female	83.4	62.3	72.8
22	Mar. 30	10	71	10	June 29	91	do	83.7	61.6	72.6
23	Mar. 31	10	70	11	June 30	91	Male	83.1	62.7	72.9
24	Mar. 30	10	73	10	July 1	93	do	84.1	61.7	72.9
25	Mar. 29	11	72	10	June 30	93	do	83.8	62.5	73.2
26	Mar. 30	10	73	10	July 1	93	Female	84.1	61.7	72.9
27	Mar. 31	10	74	10	July 3	94	do	83.6	63.1	73.3
28	Mar. 30	10	76	9	do	95	do	84.3	62.0	73.2
29	do	10	76	9	do	95	do	84.3	62.0	73.1
30	do	10	75	11	July 4	96	Male	84.4	62.1	73.2
31	Mar. 31	10	78	9	July 6	97	Female	83.9	63.4	73.6
32	Mar. 30	10	76	11	July 5	97	Male	84.5	62.2	73.3
33	do	10	78	10	July 6	98	do	84.7	62.3	73.5
34	do	10	79	10	July 7	99	do	83.8	62.3	73.0
35	do	10	80	11	July 9	101	do	84.2	62.6	73.4
36	Mar. 31	10	83	9	July 11	102	Female	84.6	63.9	74.2
37	Mar. 30	10	83	10	do	103	Male	84.4	62.8	73.6
A[1]	July 2	4	47	11	Sept. 2	62	Female	97.7	75.8	86.7
B[1]	do	4	70	10	Sept. 24	84	do	94.6	73.2	83.9
C[1]	July 4	4	74	10	Sept. 30	88	do	93.9	72.8	83.3
D[1]	do	4	83	15	Oct. 14	102	Male	92.8	70.9	81.8
E[1]	do	4	85	16	Oct. 17	105	Female	92.4	70.7	81.5
F[1]	do	4	97	14	Oct. 27	115	Male	90.6	70.0	80.3
Average		9.3	69.2	9.9		88.4				

[1] Rearings A to F inclusive are the progeny of moths that emerged from rearings 1 to 37 inclusive.

According to Table 11 the dried-fruit moth requires from 62 to 115 days to complete its life cycle. This gives opportunity for three generations in one year in unheated dried-fruit storage houses at Fresno. The insect passes the winter in the larval stage. The larvae are larger than the larvae of the Indian-meal moth, and have the same habit of prepupal migration as has that moth.

PARASITES OF THE LARVAE OF MOTHS THAT ATTACK FIGS

The most beneficial parasite of the larvae of moths that attack figs and other dried fruits is the wasplike *Habrobracon juglandis* Ashm. (Fig. 22.) This parasite has been found in large numbers where the larvae of the Indian-meal moth and of the fig moth were abundant, and undoubtedly exercises a valuable degree of control over these insects. It also kills larvae of the dried-fruit moth. Unfortunately, fumigations intended to control the Indian-meal moth and the fig moth in dried-fruit storage houses also kill the parasite.

De Ong (*11*), in writing of *Habrobracon juglandis* in California, said, "This parasite was found to be the most abundant and widely distributed of any attacking *Plodia*, in a study of insects of stored products made in 1918 for the State Food Administrator." He found certain features of its life history to be as follows: Egg stage, average 2.6 days; larval stage, average 5.2 days; pupal stage, average 7.4 days; period from egg to adult, average 16 days. The temperature ranged from 75° to 86° F. during the time these life-history records were made.

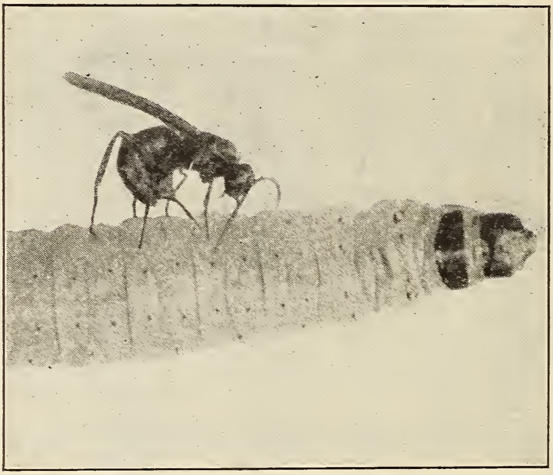

FIGURE 22.—The parasite *Habrobracon juglandis* stinging a larva of the Mediterranean flour moth (*Ephestia kuehniella*), a moth closely related to the fig moth. ×10. (Doten)

In 1928 Showell (*37*) recorded concerning the life history of *Habrobracon juglandis* as a parasite of the larvae of the Indian-meal moth that there are apparently eight generations a season in South Australia; that some females hibernate through the winter, becoming active if warmed or disturbed, and that no eggs were deposited during the winter; that the life cycle varies with the temperature, 16 days being sufficient during the summer, with temperatures from 60° to 100° F. and over; that the usual number of eggs laid on one host is 2 to 5, but that as many as 14 eggs have been counted.

Parker (*31, p. 4*) refers to this parasite under the name *Habrobracon hebetor* Say.

In 1927 some studies were made of the life history of *Habrobracon juglandis* at the dried-fruit insect laboratory, Fresno, Calif. Males and females were mated on the day of their emergence, and each pair was confined in a glass vial and given daily one living, unparasitized, full-grown larva of the Indian-meal moth. At the end of each 24-hour period the parasites were transferred to another vial, and the eggs which had been deposited beneath the body of the larva were counted. The eggs were placed between the larva and the surface on which it rested. The larvae were always paralyzed by the parasites. The paralysis frequently followed within 1½ minutes after the larva was stung by the female parasite. Stinging is not always followed by oviposition by the parasite, which may be said to sting more larvae than she can use. The females feed at the punctures that result from stinging, but the males have not been observed by the writers to do so. Data on the life history of some of these mated pairs of *Habrobracon juglandis* are given in Table 12.

TABLE 12.—*Data on the life history of mated pairs of the parasite Habrobracon juglandis on grown larvae of the Indian-meal moth, at Fresno, Calif., 1927*

Pair No.	Date of emergence of—		Pre-oviposition period	Oviposition period	Post-oviposition period	Longevity of—		Total eggs laid	Parasites developed from eggs laid		Average mean temperature during life of female
	Male	Female				Male	Female		Male	Female	
			Days	*Days*	*Days*	*Days*	*Days*		*No.*	*No.*	*° F.*
1	May 30	June 1	1	20	0	6	21	124	18	46	81.2
2	June 7	June 7	0	31	2	7	33	188	26	76	82.9
3	do	do	4	46	1	(1)	51	473	111	116	85.4
4	do	June 8	0	33	1	6	34	361	25	68	82.2
5	June 8	do	1	33	1	5	35	300	27	104	82.5
A[2]		do	1	21	1		23	172	57	0	82.3
6	Aug. 16	Aug. 16	0	13	3	4	16	112	15	31	85.7
7	do	do	0	69	3	(3)	72	661	315	74	75.6
8	do	do	0	22	0	4	22	130	28	49	82.8
9	do	do	0	42	1	(3)	43	337	73	115	78.9
B[2]		Aug. 20	0	67	1		68	602	323	0	76.1
C[2]		do	0	37	2		39	317	165	0	78.1
Average			0.6	36.2	1.3	5.3	38.1	314.7			

[1] Male escaped.
[2] Unmated females placed on egg-laying test designated by letters A, B, and C.
[3] Male removed on Aug. 18 to test length of time female will remain fertilized after mating.

Unmated females sting larvae of the Indian-meal moth and lay eggs beneath the paralyzed bodies of the larvae as readily as do mated females. The length of life of the mated females recorded in Table 12 ranged from 16 to 72 days, whereas the unmated females lived from 23 to 68 days. The total number of eggs laid by the mated females ranged from 112 to 661, and, by the unmated females, from 172 to 602.

In Table 12 are shown the total numbers of adult parasites reared from the eggs laid by each female. As many as 16 adult parasites were reared on one larva of the Indian-meal moth.

As a rule, the highest proportion of females emerged from lots of eggs laid by females with which males were present during the entire period of egg laying (Table 12), and it is clear that mating is essential to the production of female progeny. All adults that resulted from eggs laid by unmated parasites were males.

At intervals throughout the summer of 1927, egg-to-adult rearings of *Habrobracon juglandis* were made, with eggs laid by mated females. The developmental periods are given in Table 13.

Table 13.—*Data on the development of the parasite Habrobracon juglandis on larvae of the Indian-meal moth, at Fresno, Calif., 1927*

Rearing No.	Date egg was laid	Incubation period	Larval period	Pupal period	Date adult emerged	Period, egg to adult	Sex	Temperature, egg-to-adult period		
								Mean maximum	Mean minimum	Mean
		Days	*Days*	*Days*		*Days*		°*F.*	°*F.*	°*F.*
1	May 13	2	5	10	May 30	17	Male	84.8	62.2	73.5
2	do	2	5	12	June 1	19	Female	84.7	61.8	73.2
3	June 17	1	6	7	July 1	14	do	93.1	71.9	82.5
4	do	1	4	5	June 27	10	do	93.3	72.5	82.9
5	do	1	4	6	June 28	17	do	92.5	71.6	82.0
6	do	1	4	5	June 27	10	do	93.3	72.5	82.9
7	do	1	4	5	do	10	do	93.3	72.5	82.9
8	July 9	2	4	3	July 18	9	Male	99.4	77.7	88.5
9	do	2	4	4	July 19	10	Female	99.9	77.6	88.7
10	do	2	4	3	July 18	9	do	99.4	77.7	88.5
11	do	2	4	3	do	9	do	99.4	77.7	88.5
12	Aug. 16	2	4	4	Aug. 26	10	Male	96.4	75.1	85.7
13	do	2	4	5	Aug. 27	11	do	96.3	74.8	85.5
14	Oct. 16	3	7	15	Nov. 10	25	Female	76.3	61.4	68.8
15	do	3	6	15	Nov. 9	24	do	76.8	61.3	69.0
16	do	3	7	15	Nov. 10	25	do	76.3	61.4	68.8
17	do	3	7	13	Nov. 8	23	Male	77.0	61.4	69.2
18	do	3	9	11	do	23	do	77.0	61.4	69.2
Average		2	5.1	7.8		14.9				

From the eggs considered in Table 13, 12 females and 6 males emerged, a ratio of 2 females to 1 male. The egg-to-adult period ranged from 9 to 25 days, averaging 14.9 days. The rate of development was controlled to a marked degree by the temperature; for example, adult No. 8 required 9 days when the mean temperature was 88.5° F., while No. 14 required 25 days with a mean temperature of 68.8°.

At intervals corresponding to those recorded in Table 13, eggs were secured from unmated female parasites, and records were kept of their development. Results similar to those shown in Table 13 were obtained, except that all the progeny were males. Several of the insects developed from the egg to the adult stage in eight days when the mean temperature was 90.5° F.

The rapidity with which this parasite develops from the egg to the adult stage, the long life of the females, and the large number of eggs laid, are factors that make it an important control of the Indian-meal moth and the fig moth in the San Joaquin Valley. The shortest egg-to-adult interval of the Indian-meal moth recorded at Fresno, Calif., was 33 days.[5]

This interval would enable the parasite to complete approximately four generations during one generation of the Indian-meal moth.

Another wasplike parasite frequently observed in infestations of the Indian-meal moth is *Nemeritis canescens* Grav. The writers have not observed this species in large numbers, and apparently it is of little value in holding the Indian-meal moth in check.

In a few instances a small tachinid fly (*Drepanoglossa floridensis* Tns.) has been observed parasitizing larvae of the Indian-meal moth.

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[5] HAMLIN, J. C., REED, W. D., and PHILLIPS, M. E. LIFE HISTORY OF THE INDIAN-MEAL MOTH ON DRIED FRUITS IN CALIFORNIA. [Unpublished manuscript.]

THE SAW-TOOTHED GRAIN BEETLE

The saw-toothed grain beetle (*Oryzaephilus surinamensis* L.) (fig. 23) is a very small, chocolate-brown beetle, not over one-tenth of an inch long, and much flattened. The margins of the thorax are roughened with small, toothlike projections. Although these beetles have well-developed wings, they have never been observed using them in flight. The adults are remarkably long-lived, one individual having been observed to live for three years and three months (*1*).

The food of this species includes cereals of all kinds, dried fruits, nuts, breakfast foods, macaroni, and sometimes sugar, drugs, and dried meats. Food that has been stored on pantry shelves for several months is frequently found to be infested by it. Figs and other dried fruits ordinarily become infested by the saw-toothed grain beetle only after prolonged storage. However, new fruit stored near heavily infested fruit doubtless soon becomes populated with the adults. The writers have never observed the insect on ranches or in growers' deliveries of figs.

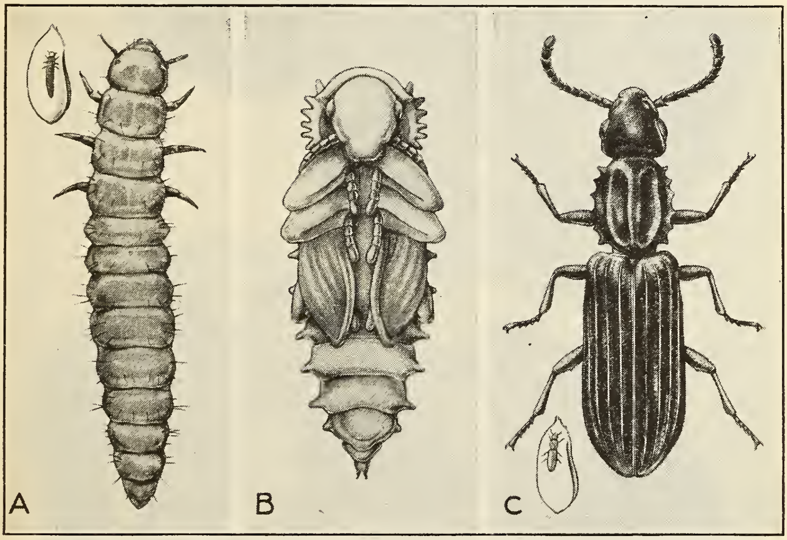

Figure 23.—The saw-toothed grain beetle (*Oryzaephilus surinamensis*): A, Larva; B, pupa; C, adult; all enlarged 21 diameters. The natural size is suggested by the illustrations of larva and adult on a kernel of wheat. (Back and Cotton)

The eggs of the saw-toothed grain beetle are laid inside of dried figs, tucked away among the seeds of the fig. According to Back and Cotton (*1*), egg laying begins as soon as five days after emergence, and the eggs laid in a 24-hour period have ranged in number from 1 to 8. Their records show that the total number of eggs laid by one female has been known to range from 45 to 285.

The larva (figs. 23 and 24) is yellowish white and when fully grown is a little less than one-eighth of an inch in length. Frequently the larvae are found in dried figs in the feeding tunnels made by the larvae of the Indian-meal moth. Back and Cotton found the larval period to range from about 4 to 7 weeks during the spring at Washington, D. C., whereas in summer this period was shortened to about 2 weeks. The shortest larval period recorded was of 12 days' duration.

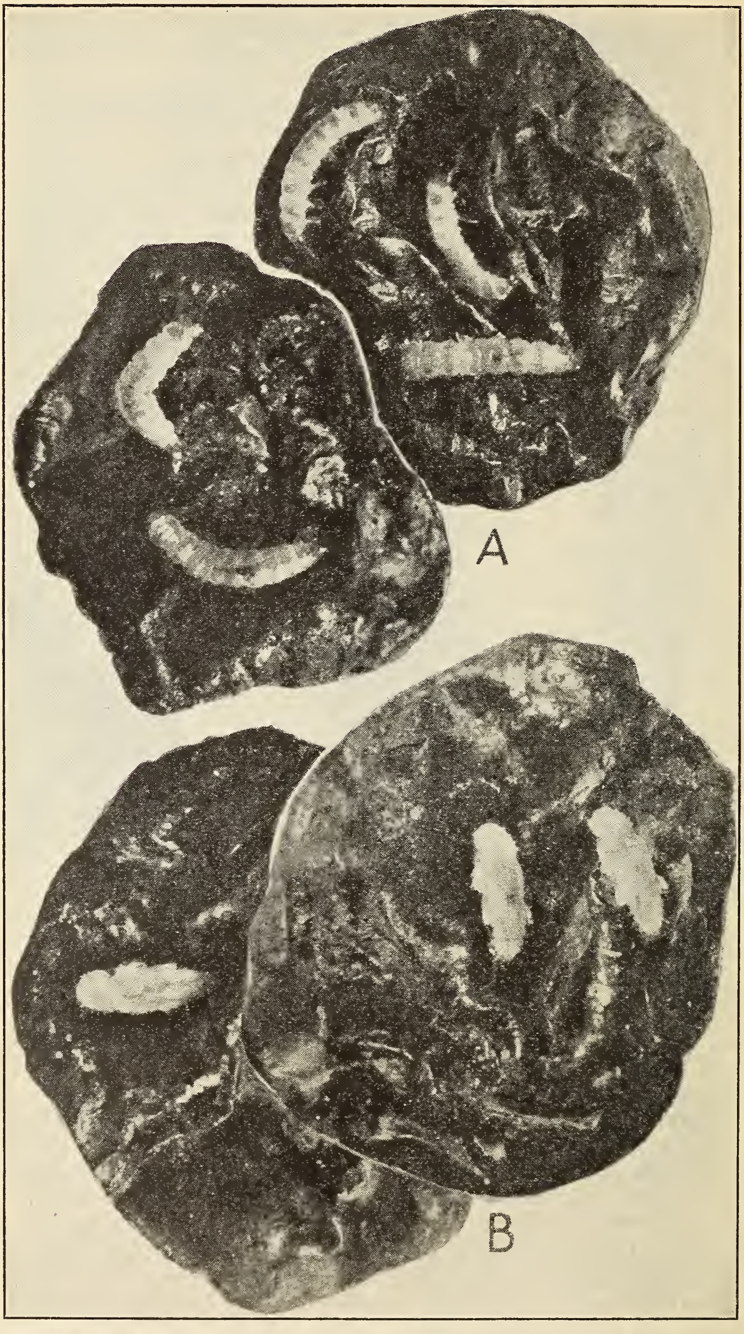

FIGURE 24.—The saw-toothed grain beetle (*Oryzaephilus surinamensis*): Larvae (A) and pupae (B) on small seedless raisins. × 7.3. (Back and Cotton)

The pupae (fig. 24) are yellowish. They are found near the feeding places of the larvae. Usually a rude pupal cell is constructed, but frequently naked pupae are found, without any protective cell surrounding them. Back and Cotton found the pupal period to range from 6 to 21 days at Washington, D. C.

A few egg-to-adult rearings of the saw-toothed grain beetle were made at the dried-fruit insect laboratory, Fresno, Calif., in 1927. Their history is summarized in Table 14.

TABLE 14.—*Data on the development of the saw-toothed grain beetle* (*Oryzaephilus surinamensis*) *on raisins, at Fresno, Calif., 1927*

Rearing No.	Date egg was laid	Incubation period	Larval period	Pupal period	Date adult emerged	Period, egg to adult	Sex	Temperature of egg-to-adult period		
								Mean maximum	Mean minimum	Mean
		Days	*Days*	*Days*		*Days*		*°F.*	*°F.*	*°F.*
1	Apr. 28	12	56	5	July 10	73	Male	88.4	66.6	75.5
2	May 16	9	30	8	July 2	47	Female	88.9	67.5	78.2
3	do	9	36	6	July 6	51	Male	89.3	67.9	78.6
4	do	8	39	7	July 9	54	Female	89.8	68.2	79.0
5	May 23	9	30	6	July 7	45	Male	88.5	69.2	78.8
6	May 26	11	52	6	Aug. 3	69	do	94.4	75.6	85.0
7	do	9	28	7	July 9	44	do	91.2	69.5	80.3
8	June 22	3	41	6	Aug. 11	50	Female	97.9	76.1	87.0
9	do	4	34	6	Aug. 5	44	Male	97.6	75.6	86.6
10	do	5	28	6	July 31	39	Female	97.7	75.9	86.8
Average		7.9	37.4	6.3		51.6				

The shortest egg-to-adult period here recorded was 39 days. Back and Cotton (*1, p. 448*) stated that "In warm summer weather, when the mean average temperature for the period of development was 81° F., three individuals required 22, 24, and 27 days to pass through the egg, larval, and pupal stages." These records, made at Washington, D. C., probably approximate the maximum rate of development for the saw-toothed grain beetle.

PARASITE OF THE SAW-TOOTHED GRAIN BEETLE

Cephalonomia (*Neoscleroderma*) *tarsalis* (Ashm.) (fig. 25) is the only parasite of the saw-toothed grain beetle that has been found by the writers. No information about the life history of this parasite has been published. The species has been reared from larvae of the beetles infesting raisins, prunes, and figs.

Heavy infestations of *Cephalonomia tarsalis* have frequently been observed in stocks of the saw-toothed grain beetle at the dried-fruit insect laboratory. Practically all of the larvae of the beetle were parasitized, and it is evident that this parasite exercises a valuable degree of control over the saw-toothed grain beetle in the San Joaquin Valley.

THE DRIED-FRUIT MITE

The dried-fruit mite (*Carpoglyphus passularum* Hering) is a light-colored, almost microscopic mite, sometimes found infesting dried fruit. The writers have observed infestations of this mite in dried figs, peaches, raisins, and prunes. According to Essig (*16*)—

> The dried fruit mite, *Carpoglyphus passularum* Hering, is a pale white species 0.40 to 0.50 mm. long, of European origin, which is being distributed in this

country, and occurs in California. It lives in and feeds on dried fruits such as figs, raisins, apples, prunes, as well as cured hams, and even the pollen paste of bees.

Infestations in dried figs have been observed in which the fruit appeared to be fairly alive with slowly crawling mites of this species. When present in such numbers they impart a somewhat disagreeable odor to the fruit. No information appears to have been secured on the life history of this mite.

THE CAPRIFYING INSECT BLASTOPHAGA PSENES L. AS A CARRIER OF ENDOSEPSIS

It is appropriate that a publication on the subject of fig insects should include some of the essential facts about the life history, pollinating function, and relation to the disease endosepsis, of the caprifying insect. Something of the history of the insect has already been referred to in the historical outline. For a summary of our knowledge of *Blastophaga psenes* L. (formerly known as *Blastophaga grossorum* Grav.), the reader is referred to the publications of Condit (*8*), Howard (*24*), and Rixford (*33*).

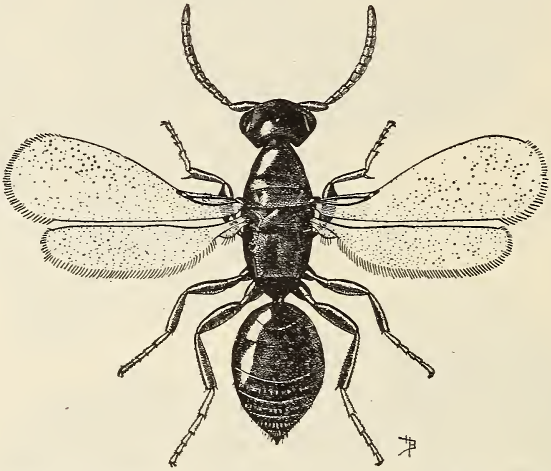

FIGURE 25.—*Cephalonomia tarsalis*, a parasite of the saw-toothed grain beetle. Adult. × 21½

The remarkable arrangement whereby the male plants of various species of fig (*Ficus carica*, *F. pseudocarica*, and others) provide food and shelter for the minute insects which bring about fertilization of the flowers of edible figs (*F. carica*) can not fail to interest all who are in any degree students of nature. Throughout the year the fruits (caprifigs) borne on these male or caprifig trees maintain a population of Blastophaga which develops within the ovaries of the specialized female flowers, or gall flowers, of the caprifigs. While still within the gall, the female insect is fertilized by the wingless male, which gains access to the female by gnawing an opening in the thin wall of the gall. After being fertilized, the female leaves the gall through the opening made by the male, and abandons the now mature caprifig in search of immature caprifigs in which to lay her eggs. As she leaves her natal caprifig (if it is a caprifig of the polliniferous spring crop) she becomes dusted with pollen from the male flowers that are grouped around the eye of the fig.

In the act of egg laying the ovipositor or egg-laying tube of the female Blastophaga is pushed down through the hollow center of the short style of the gall flower. In their search for immature caprifigs, many gravid females, covered with pollen grains, enter green figs that are borne on the female trees. However, the long styles of the flowers which line the cavity of the receptacle of the edible fig prevent oviposition in the ovaries of such flowers, and the unsuccessful attempts by the insects to deposit eggs in edible figs result only in pollination (caprification).

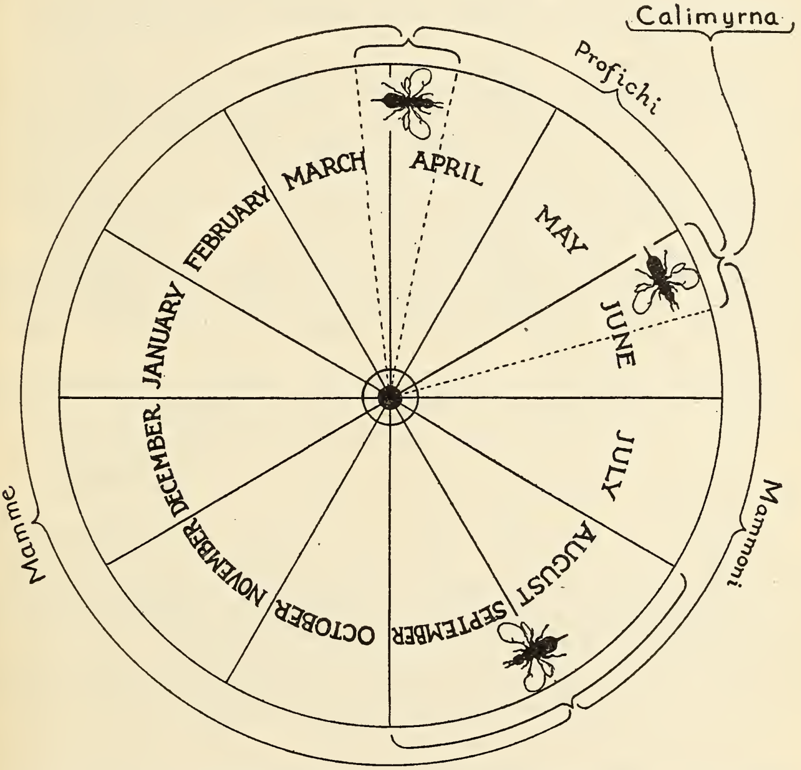

FIGURE 26.—Chart of the annual cycle of the crops of the caprifig tree (outer brackets), with the flight periods of *Blastophaga psenes* shown (inner brackets)

The development of figs of the Smyrna type is dependent upon caprification. When the flowers of varieties of figs which do not require pollination are caprified by Blastophaga, fertile seeds develop, accompanied by changes in the appearance of the figs.

Figure 26 illustrates the annual cycle of Blastophaga. The caprifigs of the spring or profichi crop are used for caprifying Smyrna figs, and are usually picked and hung in baskets in the Smyrna trees shortly before the insects emerge. As is shown in Figure 26, caprification of Calimyrna figs occurs during the first half of June.

Several years ago Caldis (*4*) discovered that spores of the fungus causing endosepsis or internal rot (fig. 3, C) are introduced into caprifigs and edible figs by *Blastophaga psenes*. Later, H. N. Hansen, of the California Agricultural Experiment Station, devised a method for securing Blastophaga free from endosepsis spores by treating caprifigs with disinfectants.

Insects other than Blastophaga have received little attention in connection with the dissemination of endosepsis. The caprifying insect is the outstanding culprit, but it is probable that dried-fruit beetles, vinegar flies, and other insects that frequent figs dripping with the by-products of the growth of the endosepsis fungus also spread the disease. (Fig. 7.)

Blastophaga psenes appears to have few enemies in California. The attention of the writers has been called to the capture of the insects in spiders' webs; and Schwarz (*24, p. 100*) observed the depredations of spiders in 1900. Cold winds are said to interfere seriously with the activities of female Blastophaga in their work of caprification, and low temperatures in winter sometimes freeze the mamme figs in which the immature insects pass the winter.

Enormous numbers of Blastophaga are usually available for caprification. A single caprifig tree may bear as many as 15,000 or 20,000 profichi figs, and a profichi fig may produce over 700 female insects (*8, p. 350, 371*). The actual egg-laying capacity of the females appears to be unknown.

Measures intended to control various insects and diseases in orchards of Calimyrna figs should be so regulated as to avoid damage to Blastophaga during their periods of flight.

PREVENTABLE DAMAGE DONE BY INSECTS TO HARVESTED FIGS

Infestation of harvested figs by the larvae of the Indian-meal moth, the fig moth, and the other insect enemies of stored figs should be classed as largely preventable damage. The extent to which the crop of 1928, while in the hands of growers, was damaged by these insects is indicated by Table 15 and Figures 27 and 28.

TABLE 15.—*Summary of results of examinations of insect-infested figs from samples of growers' deliveries, October 13–29, 1927*

ADRIATIC FIGS

Number of figs infested	Kind of insects in figs	Observed details of infestation					
		Feeding by insect	Larvae	Pupae	Pupal cases	Adults	Total observations
11,186	Dried-fruit beetle	3,768	1,761	13		1,260	6,802
	Vinegar fly	47	109	203	95	190	644
	Small darkling beetle					113	113
	Indian-meal moth	1,499	988	134	135	4	2,760
	Fig moth		496				496
	Parasite of moth larvae		15	41	22	29	107
	Total	5,314	3,369	391	252	1,596	10,922

TABLE 15.—*Summary of results of examinations of insect-infested figs from samples of growers' deliveries, October 13–29, 1927*—Continued

MISSION FIGS

Number of figs infested	Kind of insects in figs	Observed details of infestation					
		Feeding by insect	Larvae	Pupae	Pupal cases	Adults	Total observations
2,763	Dried-fruit beetle	558	231	3		32	824
	Vinegar fly				1		1
	Small darkling beetle					5	5
	Indian-meal moth	1,183	478	32	29	1	1,723
	Fig moth		157				157
	Parasite of moth larvae		3	10	4	6	23
	Total	1,741	869	45	34	44	2,733

CALIMYRNA FIGS

Number of figs infested	Kind of insects in figs	Feeding by insect	Larvae	Pupae	Pupal cases	Adults	Total observations
698	Dried-fruit beetle	257	113			19	389
	Vinegar fly				1	1	2
	Small darkling beetle					6	6
	Indian-meal moth		73	12	12		97
	Fig moth		20				20
	Parasite of moth larvae		1	5	3	3	12
	Total	257	207	17	16	29	526

KADOTA FIGS

Number of figs infested	Kind of insects in figs	Feeding by insect	Larvae	Pupae	Pupal cases	Adults	Total observations
193	Dried-fruit beetle	103	15			3	121
	Vinegar fly						
	Small darkling beetle					1	1
	Indian-meal moth	29	11	1	1		42
	Fig moth		2				2
	Total	132	28	1	1	4	166

Table 15 presents separately the indications of infestation observed in Adriatic, Mission, Calimyrna, and Kadota figs, specifying the same six insects as were named in Table 6, and following the general plan of that table. For instance, the data under the head of Mission figs show the conditions observed in 2,733 insect-infested figs of the kind named. A fig showing more than one type of infestation is recorded under more than one box head. Certain miscellaneous insects found are not included. All pupae, pupal cases, and "feeding" of the Indian-meal moth and the fig moth are recorded under the former. The larvae and pupae designated as those of the dried-fruit beetle probably included a few other species of the family Nitidulidae.

The writers have summarized several thousand records of inspections of growers' deliveries of figs of the crop for 1928, made at Fresno in the inspection laboratory of the Dried Fruit Association of California. From the summaries so made they have derived the percentages of total infestation for 5-day intervals, shown by the solid curves in Figures 27 and 28, for the Adriatic and Mission figs respectively. For a portion (August 5 to November 2) of the period covered by the solid curves the writers, from personal examinations of the insects found in the infested figs by the inspectors of that association, secured two sets of percentages of infestation; one the total infestation, as explained above, and the other the percentage of figs infested by field insects. A fig containing species which are classed as field insects was counted as having been infested in the field, irrespective of whether or not evidence of subsequent infestation by storage insects was present. Until September 3 all the figs were found to have been infested in the field, and consequently the curves for total infestation (solid line) and field infestation (broken line) coincide. After September 3, figs were found which showed infestation by storage insects only, a condition indicated by a separation of the solid and broken lines. The spread between the solid and broken curves in the case of each figure represents preventable infestation by storage insects. From the data here concerned it is estimated that the figs infested by storage insects, not including any damaged by orchard insects, amounted to about 626,000 pounds. A small part of this infestation evidently had its beginning on the drying trays, but practically all of it began after the figs had been culled and were in the sweat boxes.

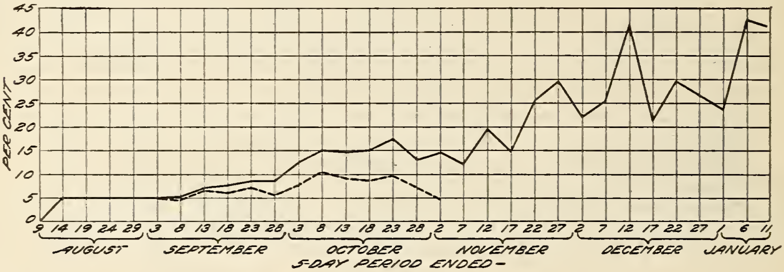

FIGURE 27.—Percentages of infestation, for 5-day intervals, of growers' deliveries of Adriatic figs, crop of 1928. Solid line, total infestation; broken line, infestation by field insects, with or without storage insects in the same figs; spread between the two curves, avoidable infestation by storage insects

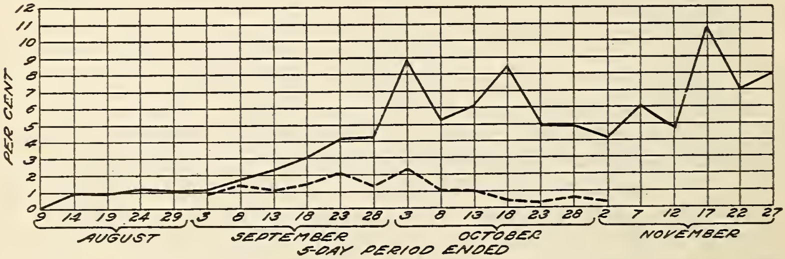

FIGURE 28.—Percentages of infestation, for 5-day intervals, of growers' deliveries of Mission figs, crop of 1928. Solid line, total infestation; broken line, infestation by field insects, with or without storage insects in the same figs; spread between the two curves, avoidable infestation by storage insect

FUMIGATION AND STORAGE ON RANCHES

In view of the widespread abundance of the Indian-meal moth and the fig moth, all varieties of figs may be expected to deteriorate because of their activities unless the crop is either marketed promptly or fumigated and stored in a tight inclosure.[6] Certain growers have realized the value of protecting figs from these pests, and in very recent years have built suitable equipment for fumigating and storing their crops. (Figs. 29 and 30.) The holding of figs on ranches without treatment and subsequent protection from insects is attended with great risk of loss through increased infestation, whether the fruit is to be packed on the place or sold in bulk as raw stock.

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[6] A statement to this effect, with suggestions for control measures, was released to newspapers in the San Joaquin Valley on Sept. 27, 1928, and Sept. 8, 1929, by the dried fruit insect laboratory at Fresno.

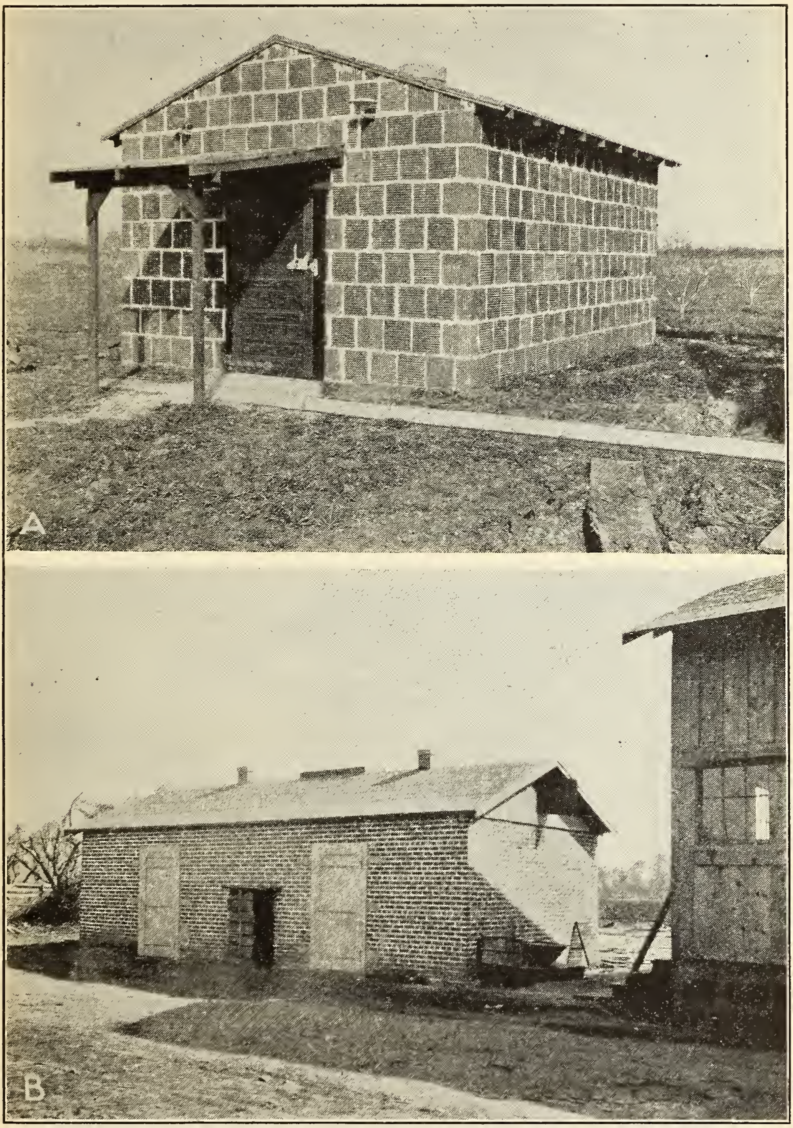

Figure 29.—Buildings recently erected at ranch packing plants in the San Joaquin Valley for the fumigation and storage of figs

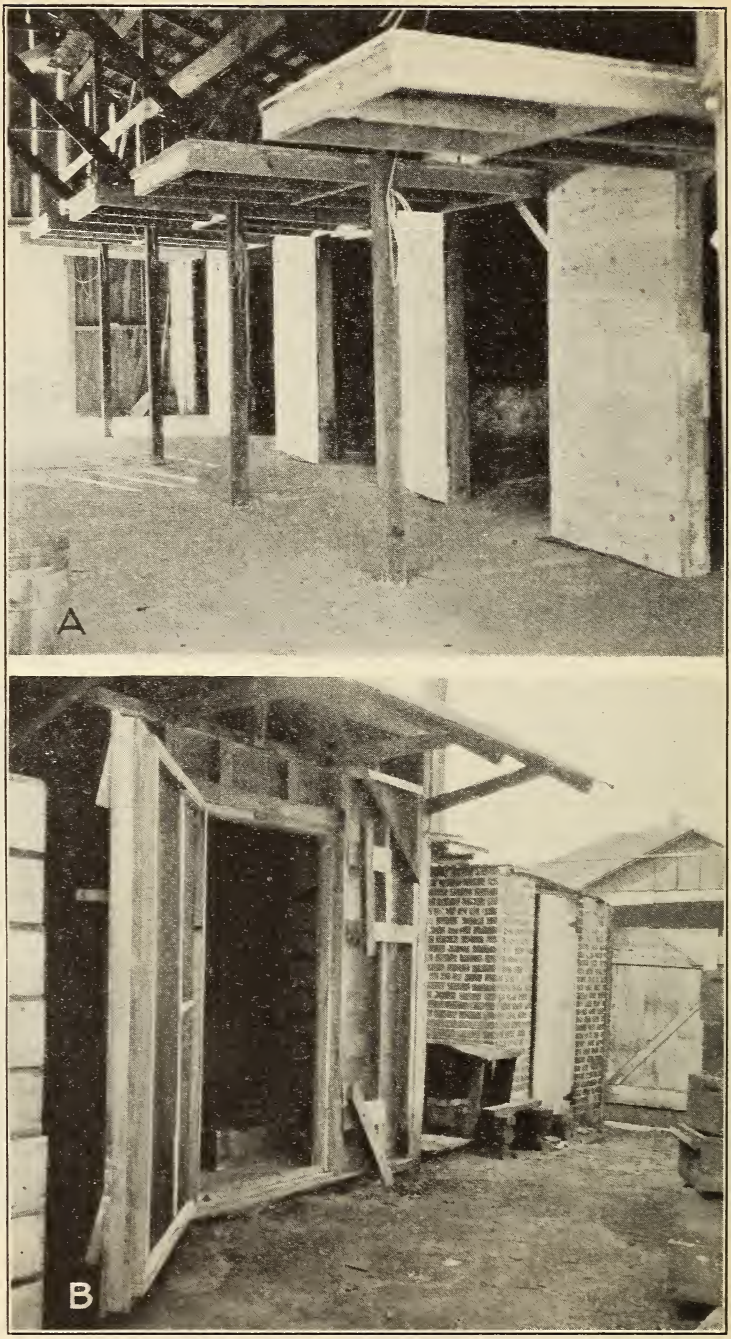

FIGURE 30.—New equipment for the protection of figs by fumigation and tight storage: A, Row of fumigable storage bins at a ranch packing establishment; B, a small, tight, wooden house that has given satisfactory service

The ideal protection for figs combines a gas-tight chamber for fumigation and an insect-tight inclosure for storage. When the temperature is not below 60° F. properly conducted fumigation in a tight inclosure destroys all insects and their eggs, and the fruit may be protected against reinfestation by tight storage after fumigation. As an additional safeguard, it is well to repeat the fumigation about once in three weeks.

As a substitute for fumigation houses, or fumigable storage bins, it is possible to utilize sulphur houses. (Fig. 31.) The walls and roofs of these houses are usually plastered and fairly tight. Some changes will usually be necessary to make a gas-tight door. The use of roofing paper between two layers of boards is suggested for the door, which should be wedged tightly against a weather strip attached to the jamb.

For the fumigation of figs on ranches carbon disulphide is probably the most convenient and inexpensive material available. The common commercial article is a yellowish, malodorous liquid which evaporates rapidly in warm weather, the resulting vapor being one of the most effective fumigants known. The dosage necessary to give a perfect kill of insects and to destroy their eggs varies with the temperature and the tightness of the fumigation chamber. If the weather is fairly warm (above 70° F.), 2 pounds of the liquid for each 100 cubic feet of space in the chamber should be satisfactory in a well-built house, with an exposure of 12 to 24 hours.

The fumigant can best be applied by allowing it to evaporate from shallow pans placed on top of the fruit. Placing it above the fruit is recommended for the reason that the vapor of carbon disulphide is heavier than air. In cool weather the evaporation of the liquid from pans is sometimes too slow; under such conditions evaporation may be aided by suspending a burlap sack above the pan, allowing the lower end to dip into the liquid. The sack functions as a wick, greatly increasing the liquid surface from which evaporation takes place. Paper may be pasted over cracks in the chamber and around the door to prevent waste of vapor and consequent poor results.

Since carbon disulphide is inflammable and mixtures of its vapor with air are explosive, fire and sparks of all kinds, excessive heat, and frictional (static) electricity should not be allowed near it. Care should be exercised to avoid breathing the fumes. In some thickly-settled communities the use of the material is prohibited.

A new and promising fumigant which may prove to be more satisfactory than carbon disulphide is ethylene oxide (*9*), a material discovered in the course of a search for better fumigants that has been carried on for several years by the Bureau of Entomology and the Bureau of Chemistry and Soils of the United States Department of Agriculture. Preliminary tests with this gas have given encouraging results. It appears to be even more effective, pound for pound, than carbon disulphide, and it apparently can be used with greater safety.

CONTROL OF FIG INSECTS IN PACKING HOUSES

Fumigating figs upon receipt and before they were graded was the general practice of packing companies during the season of 1928. In several plants large fumigable storage bins (fig. 32) have been constructed for the storage and periodical fumigation of the graded fruit. Serious infestations of dried-fruit insects can not develop in figs that

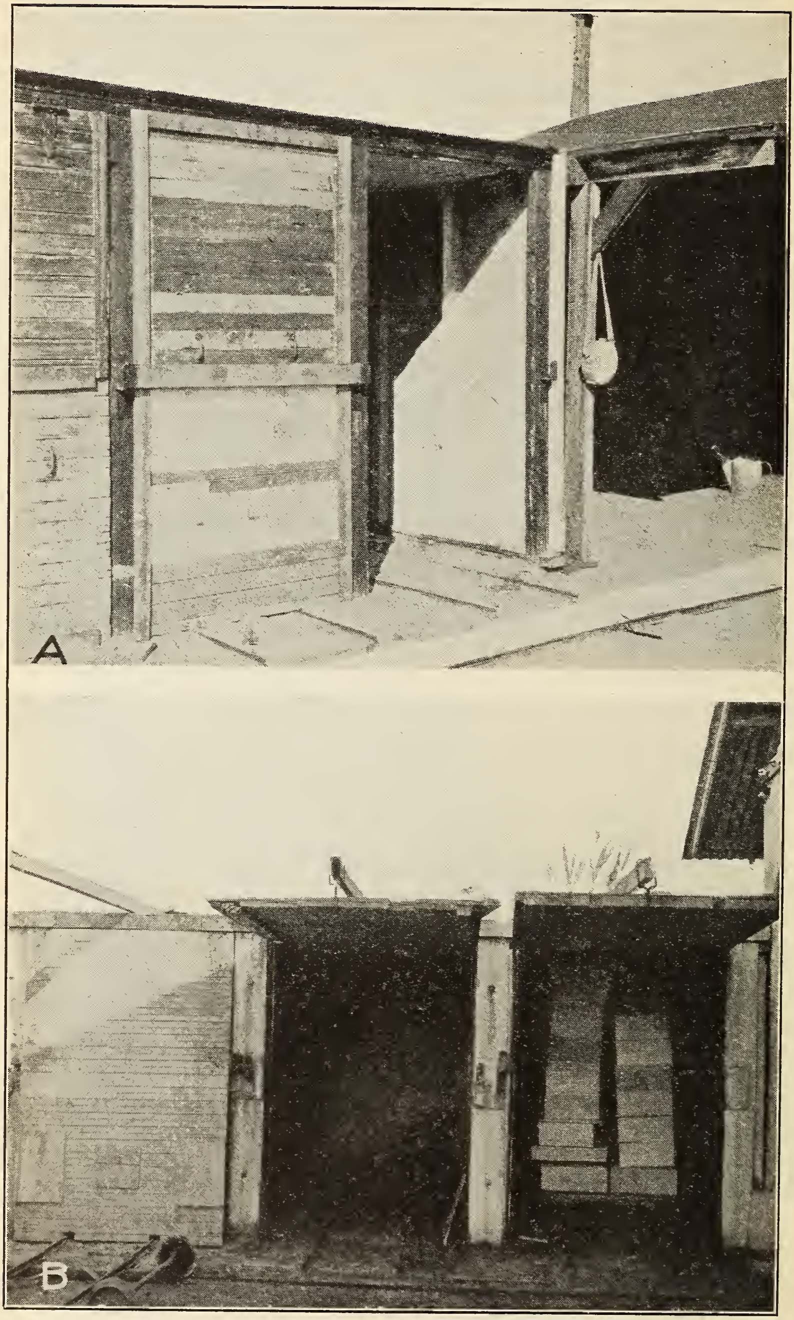

FIGURE 31.—Sulphur houses used for fumigating dried figs. By making some changes, especially in the doors, sulphur houses can be made tight enough for use in fumigation. Since fumigations should be followed by tight storage, the small capacity of sulphur houses is a disadvantage

are properly fumigated when received, and subsequently stored and fumigated in fumigable bins.

Cold storage at temperatures of 40° to 45° F. prevents growth and reproduction of dried-fruit insects, but prolonged refrigeration is necessary to kill the insects, except at much lower temperatures. Temperatures below 35° are said to result in objectionable sweating of the fruit upon its abrupt removal from the cold, which suggests the advisability of more gradual decooling. Experiments with cold storage as a control for dried-fruit insects have been reported upon by De Ong (*10*).

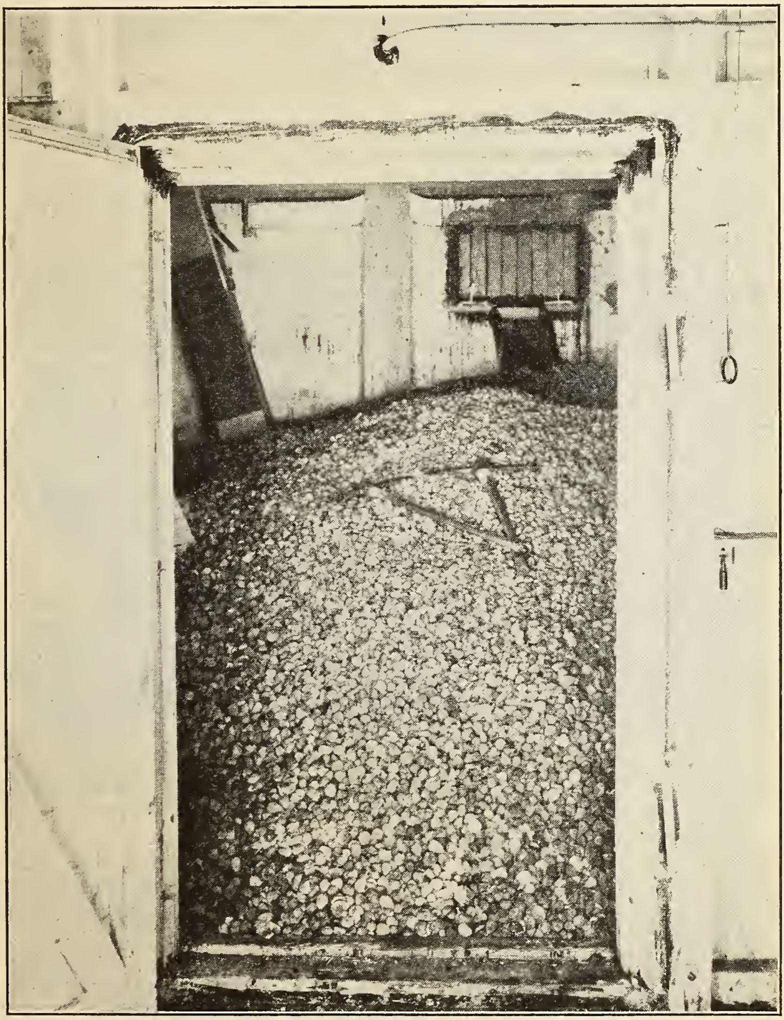

FIGURE 32.—Figs stored under excellent conditions in a large packing establishment. The fumigable storage bins, of which one is here shown, are constructed of wood, with double walls lined with roofing paper and sealed with asphaltic cement and fire-resistant paint

Investigations of the effects of cold-storage temperatures on dried-fruit insects have been made by Back and Cotton (*2*). Their results have been summarized as follows:

> The results of the writers' experiments agree largely with the findings of De Ong. An exposure to a temperature of 15°–20° F. for 3 days killed all stages of the saw-tooth grain beetle; a similar exposure to 30°–35° F. for one month killed all stages. Experiments with *Ephestia* sp., however, indicate that this insect is more difficult to kill at temperatures ranging from 30°–35° F. Thirty-two days were required to kill the egg, 34 days to kill the adults, and the larvae survived for more than 116 days. At a temperature of 25°–30° F. the larvae survived for 90 days; at 20°–25° F. for 24 days. A temperature ranging from 5°–10° F., however, killed all stages within 2 days. If dried fruit is to be stored for a considerable length of time a temperature ranging from 30°–35° F. would probably be very effective in killing out any existing infestation; if the dried fruit is known to be free from insects a temperature of 40°–45° F. or even 50° F. would be sufficient for perfect protection. If the dried fruit is to be stored but a short time and is suspected of being slightly infested it would be well to store it at a very much lower temperature, preferably below 20° F.

Both Parker (*31*) and McCharles (*28*) have discussed the insecticidal action of the hot water or steam in which figs are processed before they are packed. Referring to experiments in 10 fig-packing plants, McCharles says: "In all cases we were able to attain temperatures sufficient to destroy insect life in all of its forms without taking the figs beyond a condition which the packers considered prime for packing." Temperatures of 180° to 200° F. within figs in the center of lots that were being processed were reached in these experiments.

PESTS ATTACKING GREEN FIGS AND FIG TREES

THE MEDITERRANEAN FIG SCALE[7]

The Mediterranean fig scale, *Lepidosaphes ficus* (Sign.) (figs. 33 and 34), is thought to have been introduced into this country from Algeria about 1905, when several consignments of fig cuttings were brought to Fresno. By 1917, according to Roullard (*35*), the infestation had spread until it covered an area with a radius of three-fourths of a mile, and involved, with a wide range of severity, about 500 trees. The rate of dispersion, therefore, seems rather slow. However, the insect has spread principally in the direction of the prevailing winds, until it has now become established at points 60 miles south-southeast of the original point of infestation.

Not a great deal is known about the manner in which the fig scale spreads. Probably the young larvae, or crawlers, are the chief agency by which the infestation is carried from one tree to another and from place to place.

It has been established that the insect commonly overwinters on caprifigs. On June 29, 1917, a number of infested caprifigs were attached to a branch of a Calimyrna fig tree, which was then not infested by the scale. On July 25, 120 scales were found on the experimental branch. In another, parallel case, infested caprifigs were tied to a branch of a fig tree on June 29. On July 25, 74 scales were counted on the branch. Of these, 66 were on leaves, 2 were on petioles, and 6 on stems of the previous year's wood. In still another case 314 scales migrated from caprifigs to a branch of a fig tree during the foregoing period of 26 days. It will be seen, therefore, that caprification may be a very effective means of spreading the scale, provided that the caprifig trees are infested at the time that the caprifigs of the profichi crop are gathered and placed in the Calimyrna trees.

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[7] Notes on this insect made by R. L. Nougaret, formerly with the Bureau of Entomology, have been incorporated with those of the writer.

Wind is probably one of the chief factors involved in the spread of the fig scale, as is the case with other species of scales. Small local whirlwinds frequently develop during the summer in central California. These dust whirls have a considerable lifting effect, and no doubt detach and convey the scales, especially the crawlers, to other groves.

The fig scale lives largely upon the leaves and fruit, and on wood that is not more than 2 years old. It is occasionally found on the larger limbs and even on the trunk, but probably prefers the leaves to other parts of the tree. From 30 to 40 scales are commonly seen on a single fig leaf, and in severe cases the insects are much more numerous.

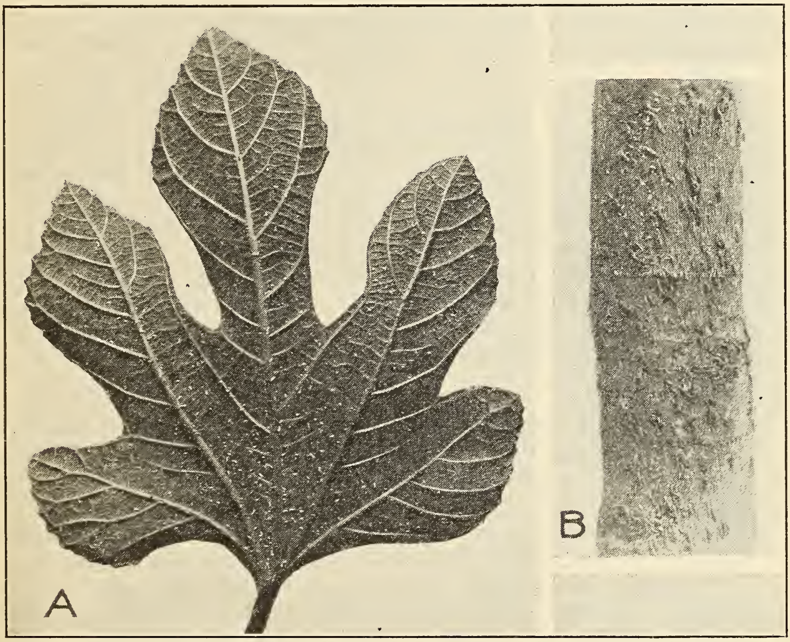

FIGURE 33.—The Mediterranean fig scale (*Lepidosaphes ficus*), A, on a leaf (× ⅔) and, B, on a twig. × 1⅔

Both the upper and under sides of the leaves are infested, the males preferring the upper surface and the females the lower. The following percentages have been obtained from counts of the male and female scales on a considerable number of leaves:

Males on upper leaf surface	76. 2
Males on under leaf surface	23. 8
Females on under leaf surface	90. 3
Females on upper leaf surface	9. 7

The presence of the fig scale on either the leaf or the fruit causes a conspicuous discoloration of the skin beneath the scale. On the leaf the spots range in color from greenish white to yellowish; on the fruit the area underlying the scales is usually of a vivid green color which contrasts conspicuously with the normal color of the fig. These spots lower the grade of ripening figs intended for canning, and impair the appearance of figs sold as fresh fruit, thus causing a direct economic loss.

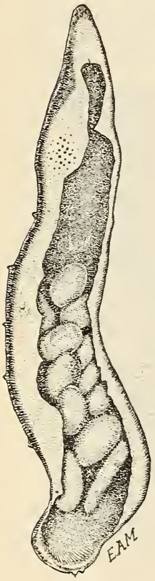

FIGURE 34.—Mediterranean fig scale (*Lepidosaphes ficus*) viewed from lower side, showing 11 mature eggs and one larva. ×50

The Mediterranean fig scale resembles rather closely the oystershell scale (*Lepidosaphes ulmi* L.), the scales appearing like miniature oyster shells. The male and female scales are much alike, except in size; they range in color from dirty white to ashy brown. The male scales are often colored a dirty orange yellow. The armor of the different generations of the females varies slightly in outline, color, and texture; the female shells of the last generation are usually the shortest, thinnest, and softest. The shells of the first and second generations are usually whitish; those of the third generation are usually brownish, with a thin, greasy coating of wax.

The eggs (fig. 34) are usually pearly white, but range in color to pinkish lavender, salmon pink, and pale purple. They are approximately bean-shaped in outline and are somewhat flattened, with one end usually slightly broader than the other. They occasionally bear spots of deeper color. The eggs of the third brood seem to be darker than those of the first and second generations. Just after hatching, the larvae or crawlers are of a light yellowish color, which gradually deepens.

SEASONAL HISTORY

It appears to be established that there are three generations of the Mediterranean fig scale each year in central California. The third generation overwinters. This brood obviously must subsist on the woody portion of the tree only, except on caprifig trees, which bear fruit throughout the winter.

Oviposition commences on different dates in different years. This date has been found to range from February 15 (1918) to March 20 (1927). In an average year, in central California, oviposition probably begins about February 25.

The date of hatching of the eggs of the first generation likewise varies from year to year. The first crawlers were seen on April 1 in 1918, whereas in 1927 they were not seen until April 20. The incubation period of the first brood appears to have ranged, then, from 45 days in 1918 to 31 days in 1927. The completion of the hatch of the first brood has occurred from April 15 (1918) to May 8 (1917), the average date being perhaps about April 30.

A few notes have been made to show the relation between the activities of the insect and the seasonal development of foliage and fruit in the spring. On March 2, 1925, the leaf buds had not yet opened, and the crawlers had not appeared. On March 22, 1927, the buds were just commencing to open, whereas, as shown above, the larvae first appeared on April 20. On April 13, 1918, the leaves were not quite fully unfurled, whereas the first crawlers were seen 12 days earlier, when the leaves were just opening. On May 11, 1928, the figs on the edible varieties had not yet formed. It will thus be seen that the first brood of crawlers usually hatches while the leaves are unfolding.

The scales of the first generation mature from about June 15 to about July 1. The peak of maturing probably is reached, in years that are nearly normal, about June 20.

The second generation is not sharply defined with regard either to the date of its beginning or that of its ending. Its development takes place approximately during the period between June 25 and August 31.

The time of the beginning of the third, or overwintering, generation is likewise very variable. However, this generation may be said to be present from about September 1 until about February 25 of the following year. There is evidence to indicate that in occasional years the third generation may reach maturity before cold weather arrives. In such cases the scales that attempt to overwinter would probably consist, in part, of a fourth generation. There is much overlapping of the several generations.

BITS OF LIFE HISTORY

The scale covering the mature female is so constructed that it almost completely incloses the eggs. Viewed from above, the shell is usually somewhat sinuous in outline; each of its side walls is expanded at the lower edge, to form within it, on each side, a flat, shelflike plate. The plates conform tightly to the supporting tissue, whether leaf, twig, branch, trunk, or fruit, but do not completely close the opening between the walls of the shell. Some of the eggs are thus allowed to be in contact with the host plant. At the front end of the shell the ventral plates are united for a short distance; posteriorly the plates practically disappear. The anterior end of the shell usually terminates in an acute angle, and the posterior end is often more rounded. The male fig scale is shorter, straighter, and narrower than the female, and usually matures a few days earlier.

Twenty-four is the greatest number of eggs that have been counted under a single shell. Counts of the egg batches of a considerable number of scales show that the average number of eggs per female is 10.9. As a rule, the eggs are loosely clustered together, usually near the posterior end of the shell. (Fig. 34.)

The newly hatched larvae, or crawlers, are usually buff or pale yellow. They crawl about actively after hatching, but soon settle down and begin feeding. In the case of the female the first molt gives rise to the second instar, the second molt to the third instar, and the third molt produces the adult scale. In the development of the male the winged adult is preceded by the prepupal and the pupal stages.

CONTROL

Various treatments have been tried for control of the Mediterranean fig scale. Table 16 presents data relating to some of them.

TABLE 16.—*Summary of experiments on the control of the Mediterranean fig scale*

Test No.	Treatment	Date applied	In charge	Results reported	Remarks
1	Cresol-turpentine-soap-distillate (cresolis compositus liquor, U. S. P., 1 quart; turpentine, 1 quart; herring-oil potash soap, 4 pounds; distillate, 32° Baumé, 4 gallons. Five gallons of the foregoing to a 100-gallon tank.)	Feb. 17, 1917	R. L. Nougaret	Not satisfactory	
2	A commercial dormant soluble oil.	do	do	do	
3	A commercial lime-sulphur (made from gas by-products).	do	do	do	
4	Cresolis soap, 8 gallons; caustic soda.	Jan. 18, 1918	do	do	Eggs hatched.
5	Cresolis soap, 3 gallons; lime-sulphur, 8 gallons; water to make 100 gallons.	do	do	Effective	Eggs did not hatch.
6	Cresolis soap, 4 gallons; lime-sulphur, 8 gallons; water to make 100 gallons.	Feb. 14, 1918	do	do	A few surviving females laid no eggs.
7	Cresolis soap, 4 gallons; soap powder, 8 pounds; water to make 100 gallons.	Feb. 15, 1918	do	No effect	
8	Cresol soap, 3 gallons; lime-sulphur, 8 gallons; water to make 100 gallons.	do	do	High mortality	No eggs deposited.
9	Carbon disulphide (fumigated all night).	do	do	No effect	
10	Potassium cyanide, 2.88 ounces; sulphuric acid, 4.3 ounces; water, 5.7 ounces (in 6 by 6 by 8 foot chamber for 1 hour).	Mar. 14, 1918	do	Effective	Examined after 24 hours.
11	Submergence 1¾ minutes in water at 110° F.	June 13, 1918	do	do	Also killed Eriophyes mites within the figs.
12	Submergence momentarily in boling water.	do	do	Complete mortality.	Blastophaga issued 4 hours later.
13	Commercial lime-sulphur, 6½ per cent.	Feb. 17, 1922	A. J. Flebut	Effective	Examined Feb. 27, 1922.
14	Commercial lime-sulphur, 10 per cent.	do	do	do	Do.
15	Commercial lime-sulphur, 12½ per cent.	do	do	do	Do.
16	Miscible oil, 6 per cent	do	do	do	Do.
17	Dry lime-sulphur (30 pounds to 100 gallons of water).	do	do	Mortality 70 per cent.	Do.
18	Dry lime-sulphur, 45 pounds; calcium caseinate spreader, 2 pounds; water to make 150 gallons.	Mar. 2, 1925	E. A. McGregor	Mortality [1] 81.8 per cent.	Weather ideal, 80° F., still. Spray rig with 150-gallon tank; pressure 275 pounds; spray guns.
19	Lime-sulphur, 15 gallons; miscible oil, 3 gallons; calcium caseinate spreader, 2 pounds; water, 150 gallons.	do	do	Mortality [1] 95.3 per cent.	Do.
20	Dry lime-sulphur, 30 pounds; free-emulsion oil, 4½ gallons; water to make 150 gallons.	do	do	Mortality [1] 94.4 per cent.	Do.
21	Free-emulsion oil, 10 gallons; water to make 150 gallons.	do	do	Mortality [1] 83.1 per cent.	Do.
22	Dormant soluble oil, 2 gallons; lime-sulphur, 18 gallons; calcium caseinate spreader, 2 pounds; water to make 150 gallons.	do	do	Mortality [1] 70.6 per cent.	Do.

[1] Net mortality, with natural mortality eliminated.

TABLE 16.—*Summary of experiments on the control of the Mediterranean fig scale*—Continued

Test No.	Treatment	Date applied	In charge	Results reported	Remarks
23	Dormant soluble oil, 3 gallons; calcium caseinate spreader, 2 pounds; water to make 150 gallons.	Mar. 2, 1925	E. A. McGregor	Mortality [1] 37.8 per cent.	Weather ideal, 80° F., still. Spray rig with 150-gallon tank; pressure 275 pounds; spray guns.
24	Lime-sulphur, 20 gallons; calcium caseinate spreader, 2 pounds; water to make 150 gallons.	do	do	Mortality [1] 77.7 per cent.	Do.
25	Petroleum oil emulsion (pale oil), 5 per cent.	Mar. 22, 1927	do	Mortality high	
26	Dormant soluble oil, 5 per cent.	do	do	do	

[1] Net mortality, with natural mortality eliminated.

In summarizing the results of experimental attempts to control the Mediterranean fig scale, as outlined in Table 16, it may be said that the only materials that have given promise of controlling the insect are oil emulsions and combinations of lime-sulphur and oil.

The fumigation and hot-water-dipping tests included in Table 16 were made for the purpose of finding a method for removing infestations of the scale from caprifigs.

According to F. P. Roullard, the scales are fed upon by a common predator, the twice-stabbed ladybird beetle, *Chilocorus bivulnerus* Muls.

THE FIG RUST MITE

A very minute mite, *Eriophyes fici* Essig, occurs commonly in the fruit cavity of edible figs, especially before the fruit is ripe. This mite (fig. 35) is invisible to the unaided eye. It is here considered to be the mite that Ewing tentatively called *E. fici* in manuscript, and which Essig (*16*) mentioned under the same name. Essig and Smith (*17*) first reported such a mite in 1922. The species may have been introduced into California from the Mediterranean countries along with early importations of fig trees and cuttings. It may be described as follows:

> Pale flesh color; body subcylindrical; thoracic region, including head, about one-third the total body length; not noticeably sculptured. Legs of medium size, leg II about ten thirty-sixths the length of the mite; subterminal "claw bristle" not knobbed, about equaling the "feathered claw" which appears to have four lateral spurs or branches on each side. Thoracic (ventral) setae II and III well developed, in length about three-eighths the width of the thorax; dorsal setae, which arise from prominent tubercles, are the strongest and longest setae, in length about equaling the greatest depth of thorax; the abdominal setae include a weak pair of genital setae, an anterior lateral pair opposite the former, three pairs of ventral setae, a pair of whiplike caudal setae, and a weak pair of setae arising from the upper posterior rim of the sucker; of the ventral setae, the first pair is the longest, third pair intermediate, and second pair very weak. The striae number from 50 to 58, the number on the dorsum and venter about equal.

The presence of the mites within figs can usually be detected by the rusty appearance of the interior parts. Rusting is sometimes severe; and yellowing and even browning of the fig flowers appears to produce, in some cases, a condition which is favorable for the growth of molds. As a rule, green figs showing no evidence of rustiness within are uninfested. Simmons and Reed state that in 1928 they found the mite prevalent in green figs throughout the San Joaquin Valley, including figs collected in an Adriatic orchard in which there was no souring. This information suggests the possibility that the species is not involved in the spread of fig diseases. It is possible that the rusty scabbing on the outer skin of figs, usually rather close to the eye, may be caused by the feeding of these mites when the figs are small.

Fig rust mites are most commonly found in green figs, and occasionally in ripe figs, but they have not been observed to infest figs that have been dried. They occur in colonies, often of several scores of individuals, and prefer the region within the fig and near the apical opening or eye. The mites feed on the flowers, pulp, and guard scales. Their activities impart a rusty color to the tissues attacked. They move about by means of their legs, but the posterior sucker is used when they have occasion suddenly to change the direction of travel, or to elevate the anterior part of the body for explorative purposes; in this act they can hold the body perpendicular to the substratum.

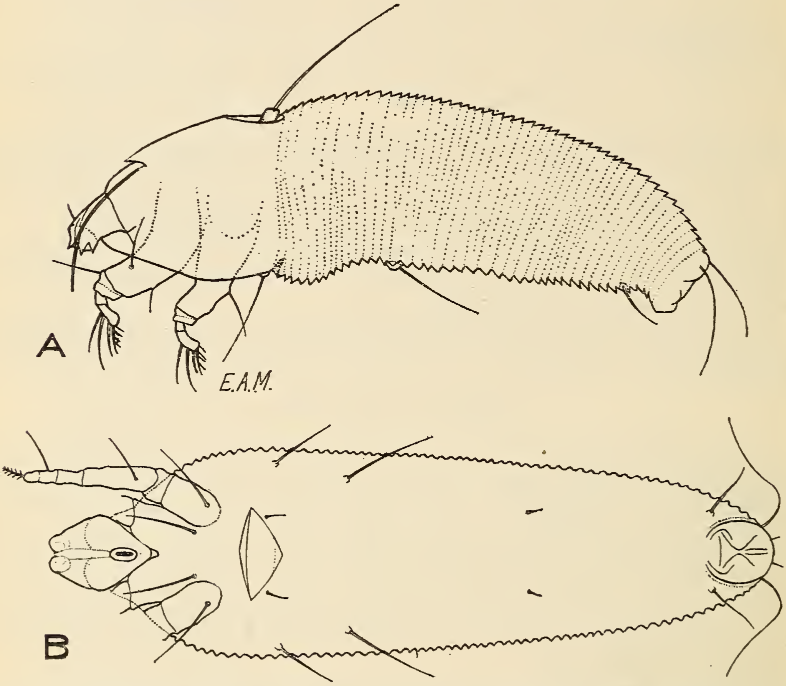

FIGURE 35.—The fig rust mite (*Eriophyes fici*). A, View from side, × 573; B, View from beneath, × 622; one leg shown, the three others amputated at the second joint. The sucker disk at the posterior end is used in locomotion

The eggs are almost colorless, nearly spherical, and very slightly flattened. They are minute, but at the same time are remarkably large in proportion to the size of the adult female mites. Deposition of the eggs takes place on the fig flowers and scales upon which the mites are feeding. The newly hatched mites are at first very pale, later becoming of a rusty straw color.

The life history and seasonal history of this pest are little known. According to Hassan (*22*) the fig rust mite hibernates successfully under the scales (probably the bud scales are meant). He also stated that he found eggs and young of the mite on fig twigs at Fresno, Calif., as late as November. No control measures against the fig rust mite are on record.

THE PACIFIC RED SPIDER

The Pacific red spider, *Tetranychus pacificus* McG. (fig. 36), is a common pest of various deciduous fruit trees, including fig, peach, prune, and apricot. It is the same mite to which, in part, the name *Tetranychus telarius* (L.) has frequently been misapplied on the Pacific coast.[8] The females of these two species are much alike, but the males are distinctly different.

The Pacific red spider occurs from Portland, Oreg., to Delano, Calif., and probably farther south. It is one of the most destructive crop pests in the Sacramento and San Joaquin Valleys, and has been rated by several authorities as the worst pest in California. In addition to working havoc to orchard crops in the State, it is a serious pest of vineyards and ornamental trees.[9] In many of the towns of central California, where municipal programs of spraying against this mite are quite common, the chinaberry or umbrella tree (*Melia azedarach* L.) and other ornamentals are annually defoliated by it. Defoliation sometimes occurs twice during a season. Among varieties of figs the preferred host is the Kadota.

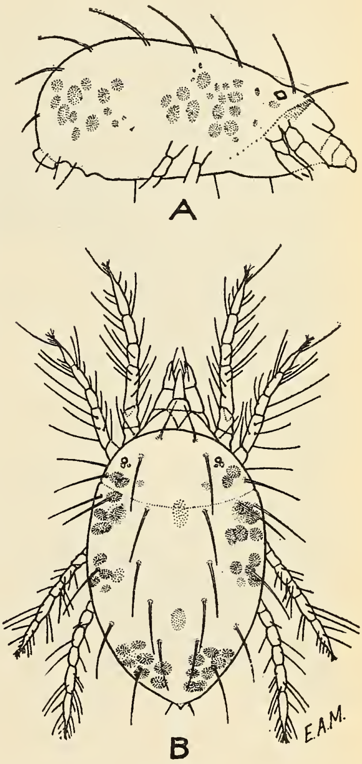

FIGURE 36.—The Pacific red spider (*Tetranychus pacificus*): A, Side view, with legs amputated; B, view from above. × 100.

Female Pacific red spiders range in color from amber to salmon and orange red, and are sometimes greenish yellow. The dorsal surface may be unspotted or marked with as many as eight blackish blotches, four along each side. The females are usually rather free from markings. The males are much smaller than the females. The eggs are spherical, at first colorless, then changing to amber. Each female ordinarily lays from 30 to 50 eggs.

Probably most of the individuals that survive the winter do so on various species of wild plants which remain green throughout the winter. In the portions of central California having the lowest winter temperatures the Pacific red spider enters a period of complete dormancy. A species of Malva (mallow) is one of the preferred hosts. On February 27, 1928, 14 females and 460 eggs were counted on a single Malva leaf. These red spiders migrate to orchard and ornamental trees as soon as the foliage of the trees develops. Females were seen on Texas umbrella trees on March 4, 1924, March 4, 1927, and February 24, 1928. The migration to fig trees doubtless occurs shortly after the leaves unfold.

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[8] There are on the Pacific coast several species of red spiders which resemble one another so closely that only a few specialists can distinguish between them. Most persons who in the past have dealt along economic lines with outbreaks of red spiders have been uncertain as to the species concerned. This uncertainty greatly limits the usefulness of the economic literature on these pests.

[9] H. E. Burke, of the Division of Forest Insects, Bureau of Entomology, rates this mite as the worst pest of ornamental and shade trees in California. E. A. McGregor, who for some years has observed the mite, is of the same opinion.

Eggs of the Pacific red spider have been observed on the foliage of trees as early as March 2 (1927) and March 10 (1924). Larvae have been recorded as early as March 8 (1927) and March 25 (1924). The first generation does not mature, ordinarily, until about the first week of April. After this date, and until the advent of cold weather, there is a succession of broods, probably a dozen or more in normal years.

The young and adults of the Pacific red spider prefer to feed on the upper surface of the leaves of certain fruit trees, and on the under surface in the case of other fruit trees, but in severe infestations the mites usually work on both surfaces.

The work of the Pacific red spider in fig orchards, as in plantings of peaches, prunes, apricots, etc., results in the defoliation and general weakening of the trees. When infestations become severe the red spiders shroud the entire foliage in a closely appressed webbing. The presence of this webbing (fig. 37) is an unmistakable sign of a severe infestation of red spiders. The pest prefers the upper portion of the tree, and defoliation is usually first noticeable there. The red spiders feed by sucking out the plant sap by means of their needlelike mouth parts.

In severe infestations the shedding of the foliage carries millions of the red spiders to the ground, and it is not unusual to see the soil in the orchards literally reddish from the myriads of spider mites which have fallen or crawled down from the trees. In such cases a secondary development of foliage often occurs, and the new foliage, in turn, is usually attacked.

Numerous insecticides have been tried against the Pacific red spider. Several of these are reported on in Table 17.

TABLE 17.—*List of treatments, arranged in chronological order, that have been used for control of the Pacific red spider, with summary of results*

No.	Treatment	Results
1	Sulphur dusting	Usually poor unless begun early and continued at regular intervals.
2	Lime-sulphur (liquid)	Better than dusting, but unreliable.
3	Lime-sulphur (dry)	Often very effective where used at rate of 8 pounds per 100 gallons of water.
4	Flour paste	Not dependable.
5	Potassium sulphide (6 pounds to 100 gallons)	Results rather poor.
6	Lime-sulphur (liquid) and wettable sulphur	Not at all consistent.
7	Lime-sulphur and miscible oil	Not dependable.
8	Lime-sulphur and gas-house sulphur	Not at all consistent.
9	Lime-sulphur (dry) and wettable sulphur	Occasionally complete control.
10	Sulphur dustings (several) and two lime-sulphur sprayings.	Fair if begun early and continued late
11	Whale-oil soap, 15 pounds; nicotine sulphate (40 per cent), 1½ pints, and water to make 300 gallons.	Unsatisfactory.
12	Neutral oil emulsion, 1⅓ per cent	Killed 89.1 per cent in one test; usually good if applied early enough.

A schedule of several dustings with finely ground sulphur has been recommended against *Tetranychus pacificus.* If this treatment is begun early enough it sometimes suffices to keep down the infestation. More often, however, dusting with sulphur is far from satisfactory. When dusting for the Pacific red spider was found to be unsatisfactory, the next recommendation to be made was a combina-

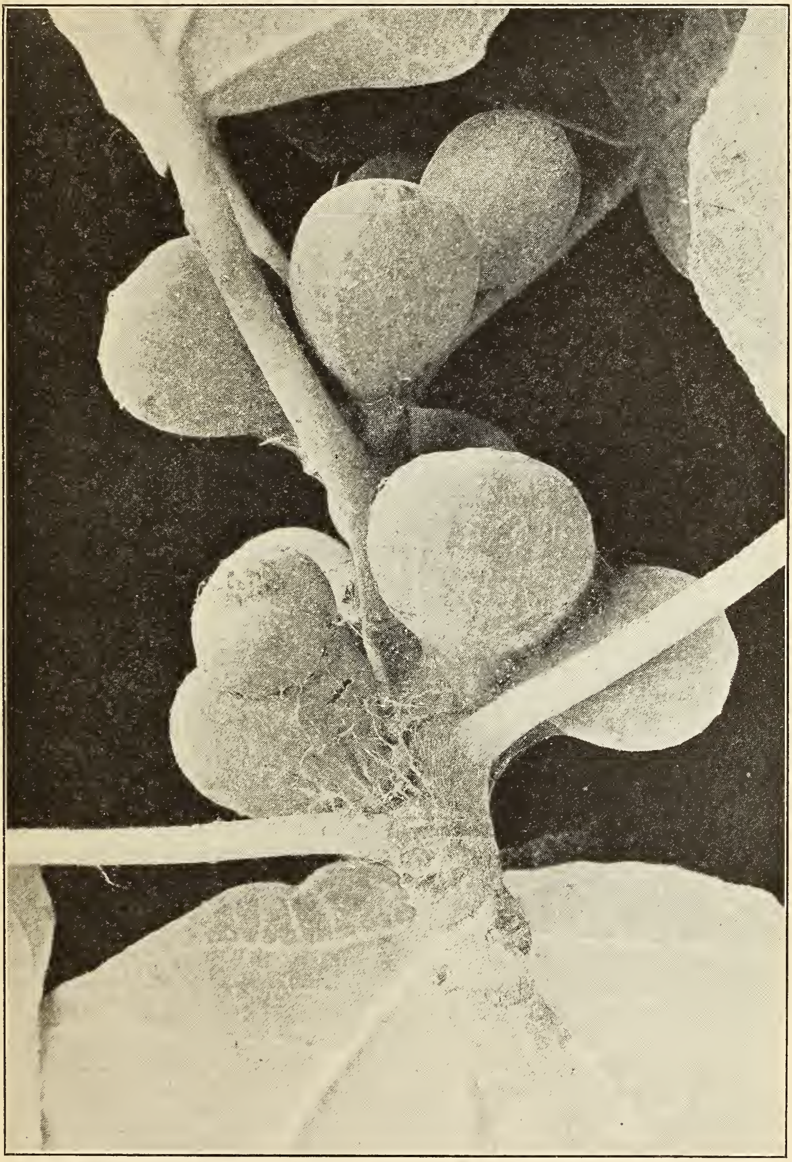

FIGURE 37.—Work of red spider on fig branch and fruit, showing webbing. × about 1½

tion spray of lime-sulphur and wettable sulphur. This proved to be an improvement, but was found to be far from certain in the control of the pest. Finally, certain neutral oil emulsions came into use against the red spider, and in most districts these emulsions have proved to be the best remedy yet employed for this purpose. Most of the eggs, as well as the active individuals, are destroyed by neutral oil emulsions. In one test, however, a commercial dry lime-sulphur proved much more effective against the Pacific red spider than did a popular brand of neutral oil emulsion. In most cases growers will be safe in using against this red spider sprays consisting of neutral oil emulsion, of which various brands are on the market.

In successful control of the red spider probably the most important point is to keep ahead of the pest. A close watch must be kept of the orchard, and the treatments must be applied before the infestation becomes at all acute. When the pest is so abundant that webbing has been formed, it is usually too late to secure satisfactory control.

Another vital point that has generally been overlooked is that most of the infestations occur in orchards that are suffering from reduced vitality, often because of lack of water. Healthy, vigorous trees usually escape the ravages of this species. One reason is that vigorous trees have denser shade and create more humidity, conditions both of which are greatly distasteful to red spiders in general, and to this species in particular. Alkali soil and other bad soil conditions, by weakening the trees, frequently lead to heavy infestations of the red spider.

THRIPS

Thrips are known to occur both inside and outside of figs in the orchard. Several species are represented in fig plantings—the grain thrips (*Frankliniella tritici* Fitch), the sunflower thrips (*F. helianthi* Moulton), the western thrips (*F. occidentalis* Pergande), and the citrus thrips (*Scirtothrips citri* Moulton) being at times involved. The species found by the writer within the cavity of the fruit have always been either the grain thrips or the western thrips. Pupae have been found in the interior of figs.

Essig (*15*) has recorded the fig as one of the hosts of the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), and of the pear thrips, *Taeniothrips pyri* (Daniel). The thrips found by Hansen (*21*) in 1928, during an investigation of the rôle of these insects in the spread of diseases into the fruit of the fig, were the tobacco or onion thrips (*Thrips tabaci* Lind.) and a species of Frankliniella, probably *F. californica* Moulton.

Direct damage to figs by thrips does not appear to be serious enough in most plantings to require the application of control measures. A type of scarring is frequently observed on the skin, but this has not yet been definitely traced to the pest or pests involved. It resembles both the work of thrips and of certain phytophagous mites. Some growers have expressed the opinion that the scarring is caused merely by the young, green figs rubbing against other parts of the plant, but it is often observed on figs that could not have been rubbed.

The citrus thrips (*Scirtothrips citri*) is occasionally seen on figs and fig foliage; however, it is by no means abundant and probably is not normally a serious enemy of this crop. In seasons of excessive abundance of the citrus thrips on citrus trees, it is quite possible that they may cause some scarring of green figs. The species is illustrated in Figure 38.

Four different lots of green figs, of 100 figs each, were carefully examined by the writer for the presence of thrips, with the result that 13 of the insects were found. When 2,130 green Adriatic, Mission, and Calimyrna figs were examined in August, 1928, by Simmons and Reed, thrips were found in 18 figs, an infestation of 0.8 per cent. The infestation of several samples reached 4 per cent, but about two-thirds of the samples contained no thrips. Infestation by thrips in several thousand hard, green, uncaprified figs, examined by Hansen (*21*) in May, 1928, amounted to about 20 per cent. These figs were of the Calimyrna, Adriatic, Mission, and Kadota varieties, and were collected from various parts of the State. Thrips are rarely found in dry figs.

On May 11, 1928, a census of the thrips population of 40 branchlets on fig trees was made by the writer by means of a pest gauge, a device for taking comparable samples of small insects from foliage (*29*). No figs had yet formed. A total of 56 thrips were thus captured, an average of 1.4 thrips per branchlet. They all appeared to be the so-called "grain" thrips. On June 5, 1928, when numerous small, green figs were present, the pest gauge was again used on 40 fig branchlets. Seven adult grain thrips, eight larval grain thrips, and one adult citrus thrips were captured, a total of 16 thrips, and an average infestation of 0.4 thrips per branchlet. When compared with the occurrence of thrips on some crops, these results indicate very light infestations.

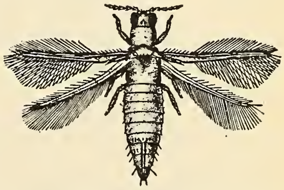

FIGURE 38.—The citrus thrips (*Scirtothrips citri*) viewed from above. × 31. (Horton)

Hansen (*21*) has presented preliminary evidence which indicates that thrips which enter hard, green figs in May inoculate such figs with various bacteria, fungi, and yeasts capable of producing conditions of disease in ripening figs.

MISCELLANEOUS PESTS OF FIG TREES AND FRUIT (USUALLY UNIMPORTANT)[10]

The following insects are listed by Essig (*15*) as among the species which attack the fig:

Aspidistra scale, *Hemichionaspis aspidistrae* (Signoret).
Black scale, *Saissetia oleae* (Bernard).
Cottony cushion or fluted scale, *Icerya purchasi* Maskell.
Florida wax scale, *Ceroplastes floridensis* Comstock.
Greedy scale, *Aspidiotus camelliae* Signoret.
Oyster-shell scale, *Lepidosaphes ulmi* (Linné).
Pernicious or San Jose scale, *Aspidiotus perniciosus* Comstock.
Purple scale, *Lepidosaphes beckii* (Newman).
Red scale, *Chrysomphalus aurantii* (Maskell).
Soft brown scale, *Coccus hesperidum* Linné.
Long-tailed mealybug, *Pseudococcus longispinus* (Targioni).

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[10] A rather small pale mite of the family Eupodidae may frequently be found on and in green figs. An examination of 300 such figs in the summer of 1927 resulted in the finding of 64 of these mites, or about 1 mite to each 5 figs. The preferred habitat appears to be the outer surface of the fruit, but the writer has occasionally observed them passing in and out of the apical opening. No appreciable damage has been observed to result from its presence.

Citrus white fly, *Dialeurodes citri* (Riley and Howard).
Branch and twig borer, *Polycaon confertus* Leconte.
Western twig borer, *Amphicerus cornutus* (Pallas).

The citrophilus mealybug (*Pseudococcus gahani* Green) has recently been reported (*36*) as occurring in all its stages inside of figs, in southern California.

A small bug, probably the false chinch bug, *Nysius ericae* (Schilling), has been observed, near Fresno, damaging fig foliage, to which it sometimes migrates in large numbers after the drying of the grasses and weeds on unirrigated areas.

SUMMARY

In California, the leading fig-producing area in the United States, the fig tree and its fruit are affected by a variety of both insects and diseases. The small branches and foliage, as well as the developing fruit, are attacked to some extent by the Mediterranean fig scale and by the Pacific red spider. The most successful controls for the former are certain oil emulsions and combinations of lime-sulphur and oil. Control of the Pacific red spider is sometimes attained by early application of finely ground sulphur, but more reliable results are usually obtained by the use of one of the several brands of neutral oil emulsions.

The fruit of the fig while still hard and green is entered by a microscopic rust mite which causes a brownish discoloration of the flowers, especially around the eye of the fig, but no control measures against this species have been attempted. Thrips are in somewhat the same economic position, although there is increasing evidence that their presence in figs is correlated with the development of various organisms which cause rots and molds.

A number of other species of insects, scale insects for the most part, have been reported as infesting fig trees and fruit, but usually not to an important extent.

During the green stage of figs they are entered also by the caprifying insect (Blastophaga), which bears upon the surface of its body not only the pollen grains which serve to pollinate the fig flowers but also spores of a fungus causing the disease known as endosepsis or internal rot. This insect of course affects primarily the Smyrna type of edible fig, which requires fertilization in order to develop, but other varieties of figs, growing within range of the flight of Blastophaga, are entered indiscriminately.

As the fruit begins to ripen and to become sweet and soft, the apical opening or eye usually becomes larger, and the insects which are attracted to the figs at this stage are able to enter them for the dual purpose of feeding on the pulp and of laying their eggs. Of these insects the most important are small beetles, of the family Nitidulidae, and vinegar flies. The evidence in favor of the conclusion that these insects carry into figs the yeast cells and bacteria which bring about souring of the fruit is very conclusive; and it is supposed, but with less dependable evidence, that the same insects are responsible for the introduction into figs of the spores of a mold which produces a disease known as fig smut. After the ripe fruit has fallen to the ground it is at times, and usually in restricted areas, damaged by the feeding of small darkling beetles.

The problem of the control of the insects, considered above, which seriously damage the ripening or ripe fruit in the orchard has not been solved. Sanitation of the orchard and ranch, consisting of the elimination of the breeding places of the nitidulid beetles and vinegar flies, is strongly to be recommended. Traps have been devised for the capture of large numbers of these beetles, but the efficiency of traps, in their present stage of development, is not high enough to result in control. Traps are most effective when used in March, April, and May, before any figs have ripened. The control of small darkling beetles has not been satisfactory, in general, but there are reports to the effect that the application of poisoned bait is probably the most satisfactory measure against them.

Figs that are dried and ready for sale are seriously damaged by the larvae of the Indian-meal moth and fig moth. This injury begins on the ranches, where the fruit is dried and stored temporarily in boxes, and continues to develop in packing houses unless the fruit is fumigated and stored in insect-tight inclosures. Dried figs that still contain considerable percentages of moisture continue to be suitable for the development of nitidulid beetles and of vinegar flies. Saw-toothed grain beetles are, as a rule, found only in figs that have been well dried during several months of storage.

If care is taken to prevent fire, carbon disulphide may be used for the fumigation of figs in storage on ranches. A safer fumigant, for use both on ranches and in packing houses, is a recently developed material known as ethylene oxide. It may be said that damage to stored figs by the insects which infest the dried product is largely preventable by prompt fumigation under favorable conditions followed by storage in insect-tight rooms or bins. It is possible also to employ low temperatures for the control of these insects, and the temperatures reached by the fruit during processing in hot water may be so regulated as to insure the death of insects within the figs. Both sulphuring operations and drying in the heat of the sun apparently kill some insects, but such exposures can not be depended upon to give satisfactory control.

The activities of several parasites of the insect enemies of figs have been observed, and one of them, a parasite of the larvae of the Indian-meal moth and fig moth, has shown itself to be an important factor in reducing the numbers of its hosts.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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